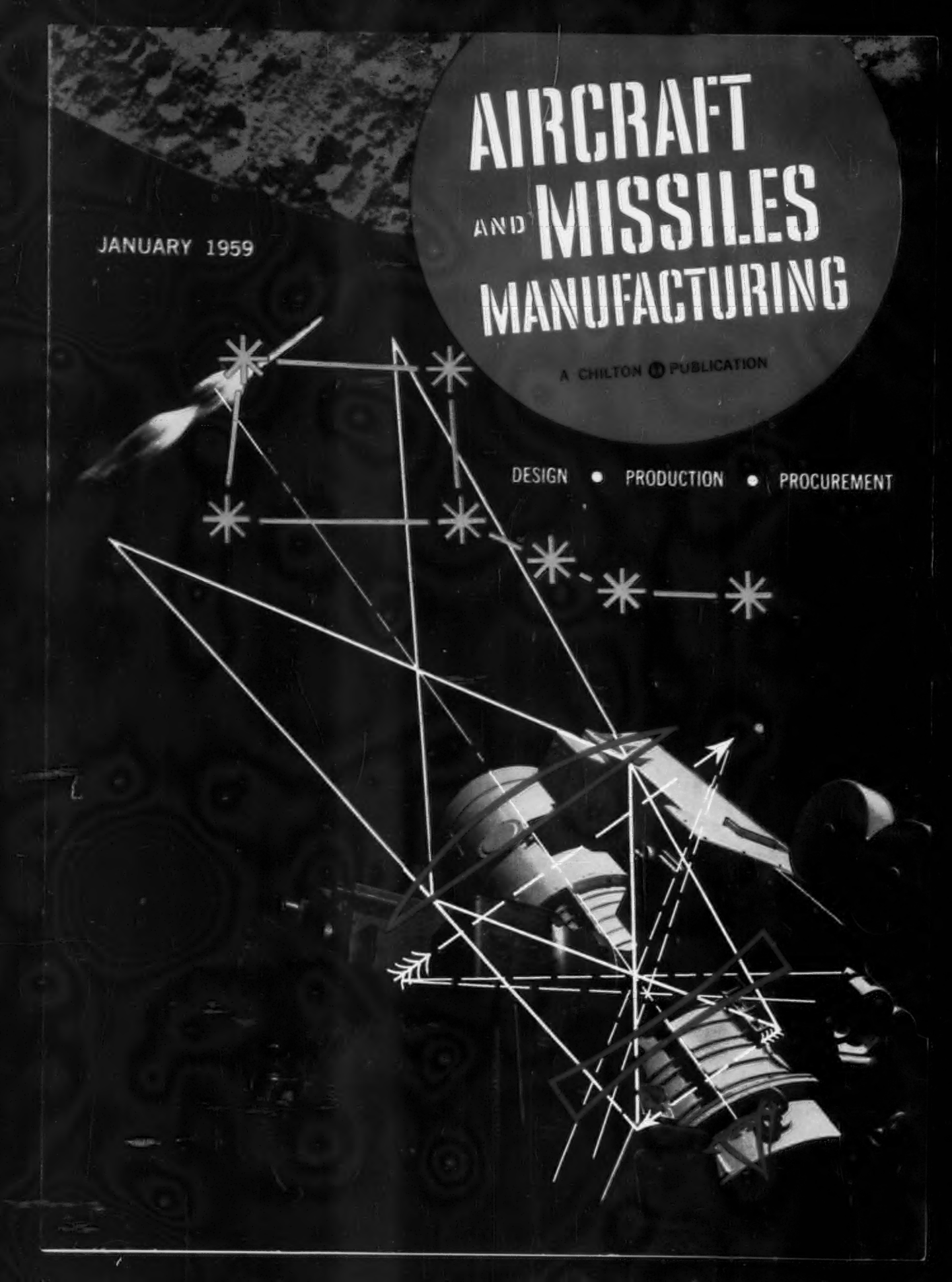
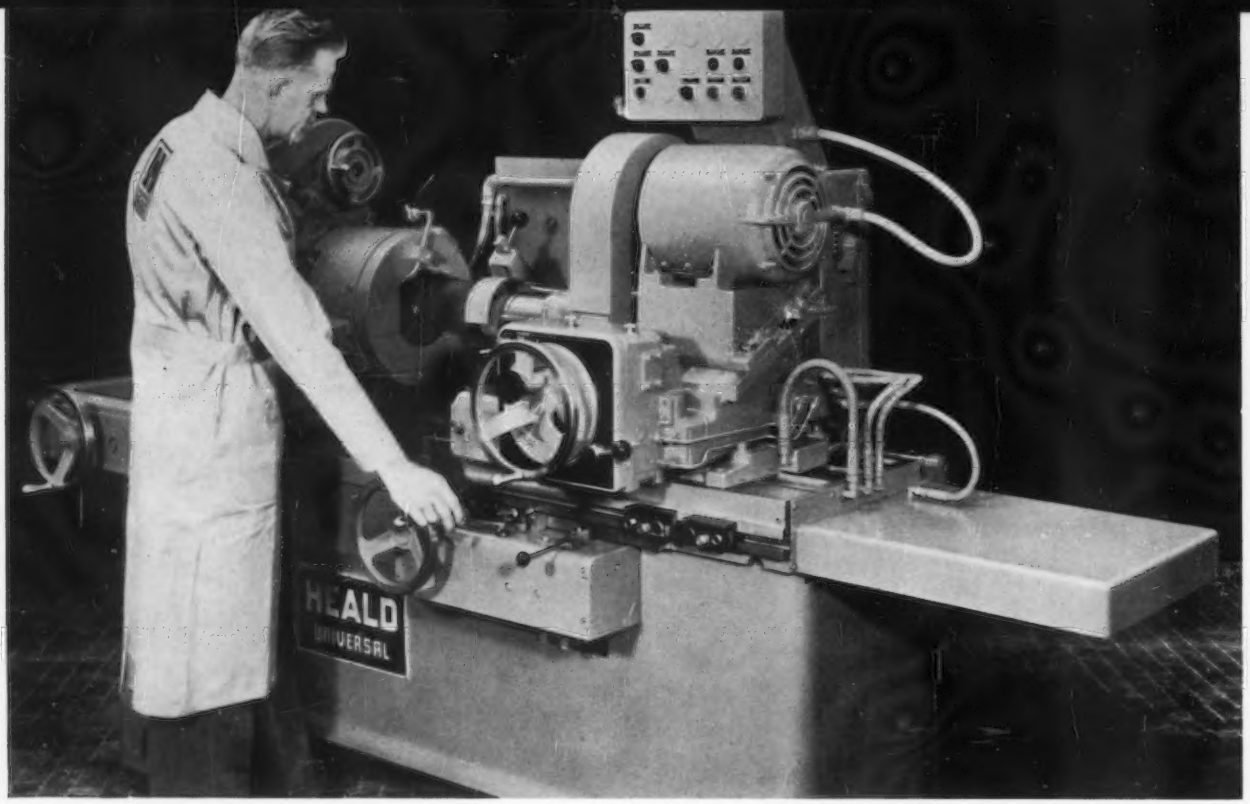
AIRCRAFT AND MISSILES MANUFACTURING

JANUARY 1959

A CHILTON PUBLICATION

DESIGN • PRODUCTION • PROCUREMENT





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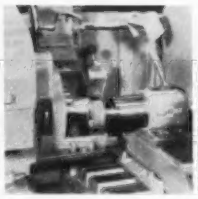

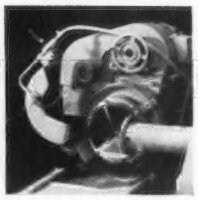

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Circle 21 on Inquiry Card, page 81

the first real "BREAK" *for airborne harnesses*

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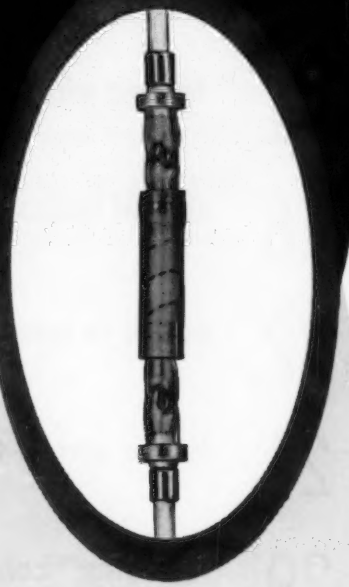

FEATURES

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FEATURES

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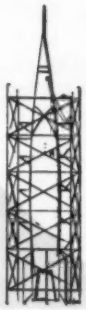

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JANUARY 1959
volume 2, number 1
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PAGE

6 optics and reliability

11 tooling with optics

16 role of optics in Snark

22 optics in quality control

24 hands across the drawing board

29 "growing" components by electroplating

34 non-rigid airships

38 Alouette II

43 quality control in ballistic shells

48 brazing aluminum to stainless

50 electrolytic machining of honeycomb

THE COVER STORY

The line diagram on this month's cover represents the basic optical principle of Galileo's telescope. His basic motive for developing this simple yet efficient system was to bring heavenly bodies closer for study. Several centuries hence, ramifications of the same optical system are being used for the same purpose. This time, the approach is different; now man is preparing to get nearer to the heavens, by using optics to build his space vehicles.

departments

PAGE		PAGE	
4	editorial orbit	57	new for production
53	producibility review	62	men on the move
55	materials and components	65	worth asking for
		80	your date book

industry notes

PAGE		PAGE	
67	basic research: unlocking the secrets of science	74	pre-packaged powerplants
69	heat put on hidden flaws	75	machining graphite
70	radio telescope to pierce space	75	jetliners digitized
70	close-up films of satellites	75	tie-down brackets
70	radar guides missile	76	rating a radome
71	terra-scope	76	sights set
72	bargains increase in piston class	76	high thrust engines tested
72	trainer simulates propulsion system	76	mach 10 speeds sought
72	Bomarc under duress	77	wind tunnel nozzle
73	optical industry looks to space	77	technical prospect
		78	industry statistics
		79	Firebee facts

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Circle 25 on Inquiry Card, page 81

new adventures in '59

Man hurtling into space gives a special excitement to the 1959 aircraft and missiles economy. This and other projects of the industry will add almost $15 billion to the gross national product.

Our industry has put four satellites into orbit, sent two probe vehicles over 60,000 miles into space, obtained preliminary but valuable biological information by sending a primate into space, and given manned vehicles true supersonic capability. Now for greater things. Among them, hypersonic aircraft—chemically and atomically fueled, ballistic recovery of orbiting man, and TV surveillance of Earth and other plants.

The price of these achievements is costly research, development, and production—behind it all is money.

An estimated $3.3 billion will be spent on missiles and $6.9 billion for military aircraft procurement. These represent the major portion of our defense budget for '59.

Emphasis on development and reliability will take almost $800 million. Missiles will receive $513.7 million and aircraft $245.8 million for pure research.

And in the dramatic, changing civil aviation picture, revolutionary commercial jet airliners are setting a surging economic pace. Value of orders being processed by turbine transport manufacturers is about $3.0 billion. This includes more than 600 new aircraft. Orders for engines and special equipment total another $0.5 billion. Additional billions will be spent on Jet Age accessories, training, merchandising, maintenance bases, and traffic control equipment.

Employment in the industry as a whole should level at about 800,000, as firms continue their drives to conscript top engineering talent.

Editor

IN THE COURSE OF EVENTS

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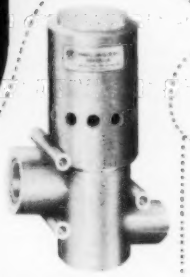

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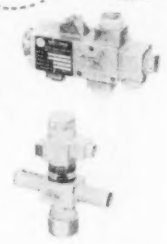

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Circle 26 on Inquiry Card, page 81

optics aid reliability

Optical systems which provide a permanent film record of critical first stage behavior are important in reliability studies. Photo records are often the only means of determining what occurred during malfunction or break-up

tracking and recording devices provide accurate information on launch; feed-back on malfunctions essential to missile development

by George A. Economou,
staff engineer, Perkin-Elmer Corp.

The advent of the ballistic missile has brought with it an increased demand for optical systems capable of long-distance tracking and recording of missile flight behavior. Such systems are important in developing missile reliability. For, in some cases, photographic records are the only means of determining what actually happened during a malfunction or break-up.

Basically, three types of optical photographic units are used on missile test ranges:

- Metric systems
- Documentary cameras
- Sequential cameras

Metric systems provide angular measurements (azimuth and elevation), and are used to obtain position data and to calibrate electronic tracking equipment. Documentary cameras are used to cover a specific portion of a missile's trajectory, and usually do not record a time signal on the film. The third type, the engineering sequential camera, is becoming increasingly important. In addition to providing long focal length and high angular resolution, it exposes a time code signal on the film so that in later study a specific event can be correlated to the exact moment of occurrence.

ROTI Mark II (Recording Optical Tracking Instrument), manufactured by Perkin-Elmer Corp., has been installed at various points on Atlantic missile range. Can track missile automatically or semi-automatically. Protective dome is not shown.

The ROTI Systems

Among the cameras of this type is the complex ROTI (Recording Optical Tracking Instrument) Mark II. Three of these seven ton systems have been installed to date on the Atlantic Missile Range—at Melbourne Beach and Vero Beach, Florida, approximately 40 and 50 mi south of Cape Canaveral respectively; and on San Salvador, W.I.F., some 400 miles down range.

ROTI has a highly corrected 24-in. objective telescope, with focal lengths that can be varied up to 500 in., by 100 in. steps. It can be operated by remote control or by aided tracking. Under remote operation, range radar signals are fed into the ROTI station, passed through computers, and into the instrument to keep it on track. The aided tracking mode, however, is used almost exclusively, with one operator handling azimuth and a second handling elevation.

The aided tracking system actually represents a closed-loop servo, with the operator inserted in the loop. Pressure on the "stiff stick" knob is translated into electrical impulses that drive a hydraulic servo. This servo in turn develops mechanical torque to drive the system mount.

ROTI is equipped with both automatic focus and automatic exposure. The auto-focus is driven by range radar signals. The auto-exposure is preset to give a uniform, optimum exposure to the type of film being used. When coupled with optimum film processing this maximizes the image contrast. During the track, the unit automatically compensates for changes in the sky background.

continued on next page

Semi-automatic, or aided, tracking is used most often with ROTI. One operator handles azimuth, second handles elevation. Infrared unit will soon be attached to all ROTI installations to allow more reliable night photography.

Close-up shows operator's controls. Primary control device is small white knob, called "Stiff Stick." Pressures on this control are translated to electrical impulses that actuate a hydraulic servo. Servo develops mechanical torque to drive mount.

Visual null is another important feature of the system. It permits the operator to follow the missile, even when it is temporarily lost to his eye because of cloud cover or like condition. Visual null gives the operator a radar determined vector through an eyepiece which guides him to the target being tracked by the radar.

Systems such as ROTI are used to increase the distance at which missile behavior can be observed. They are used initially to document any peculiarities (unusual attitude or structural failures) in the flight, or unusual occurrances in relation to flame burning. They are also extremely helpful in shock wave studies of flame patterns, and for detection of after-burning.

Contractor Decides

When a launch is scheduled, the missile contractor stipulates the type of information needed. Requirements are submitted to the RCA Instrumentation Control, which determines if the request can be fulfilled and selects the instruments for use on the missile. The operational instructions are given to the station crew prior to the missile test. ROTI, along with all other instrumentation on the Atlantic range, is operated by RCA Service Corporation which has technical surveillance over the range.

Immediately after a launch, film is removed from the camera and a crew critique is held. A data sheet, giving pertinent operational data (focal length, frame rate, shutter angle, weather data, instrumentation performance, footage, type of film emulsion), is prepared to accompany the film to the processing lab.

The film is processed, and taken to Instrumentation Control where it is evaluated from the point of view of systems performance. Hence, if some malfunction in the camera system is evident, corrective action can be taken before the next launch.

If the system has been used to obtain attitude data (roll, pitch, yaw), it next goes to Data Reduction where measurements from the film and that from other cameras are correlated to the time of the missile launch. At least two optical instruments which provide time coding on the film are necessary to obtain attitude data.

Much of the ROTI footage falls into surveillance or engineering sequential information which is time correlated. This film by-passes Data Reduction and goes directly to the missile contractor. When engineering sequential information is desired, one photo optical instrument is sufficient to provide it.

In the case of a particularly "hot" mission, this normal route is short-circuited. The film is rushed to film processing for quick prints and immediately delivered to the missile contractor.

Cine Theodolites

The large ROTI dwarfs another tracking device used to diagnose missile behavior by means other than long distance photographic surveillance.

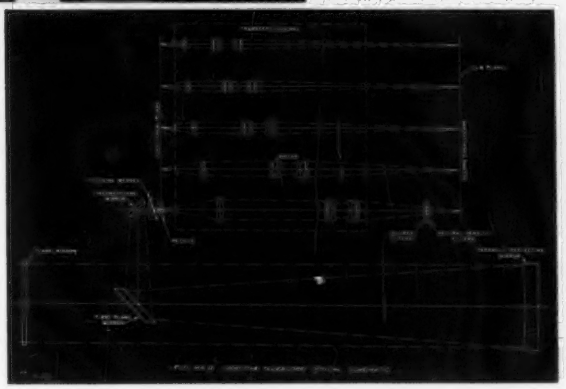
To exactly determine the position, velocity, acceleration, trajectory and attitude of guided and unguided missiles, a relatively small and compact dynamic surveying tool called a cine theodolite is used.

Basic Trajectory Information

The cine theodolite secures basic missile trajectory information more precisely than radar. Radar distortion due to ground clutter, reflections from terrain at low elevation angles, are naturally eliminated by an optical system. Greater redundancy of data intake is also permitted.

A minimum cine theodolite system consists of two or three cine theodolites properly placed at exactly predetermined ground positions. This arrangement assures optimum geometry as the target moves. In most cases four or more theodolites are employed to avoid any positional

Smaller optical tracking unit is the cine theodolite. Several of these units are used to make up a tracking "system." Low altitude tracking is chief function, where radar is at times ineffective because of ground return.



ROTI has highly corrected 24-in. objective telescope. Focal lengths are variable up to 500 in., by 100-in. steps. Pictures taken with ROTI led RCA engineers to calculate length of Sputnik is at 79 ft, ± 5 ft.

error, to increase intersection angles, increase redundancy, and improve reliability.

The complex cine theodolite — a marked contrast to earlier systems—is now a familiar "workhorse" at firing ranges and is considered an essential tool in evaluating the reliability of all classes and sizes of missiles and rockets. Probably the main contributor to the rapid advance in the art of designing these units has been the blending of electronics, optics and mechanics, and the advent of the "systems concept" that packages of three together to create a dynamic unit.

The cine theodolite scrutinizes and records on film the behavior of the critical first stage. At this early phase in flight it can be determined whether the vehicle is following its programmed flight path. Equally critical burnout and fallout behavior may also be observed in certain cases.

A master station controls and monitors operation of the two or more properly spaced theodolites by cable or radio connection. This station synchronizes the release of the camera's venetian blind shutters on the various theodolites. The station also records the instants at which the exposures are taken.

An electronically-driven 35-mm camera, permitting a frame rate of five-exposures per sec is used. Solenoid-operated shutter speed is 1/150 sec and film capacity is 1,000 frames. The time of actual exposure of each frame is recorded at the master station with an accuracy of better than 1/1000th sec.

The overall accuracy of the data allows the determination of azimuth and elevation angles with an accuracy of plus-minus 4 sec of arc.

The camera follows the object directly, by manned control, or by means of a semi-automatic aided tracking control. At instant of exposure, sections of the graduated elevation circle and of the graduated azimuth circle, along with veniers and the number of exposure, are photographed on the image. Thus the photograph gives the azimuth and elevation angles of optical axis and camera.

◆

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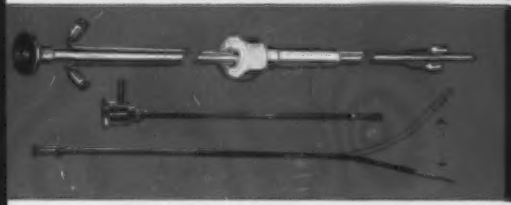

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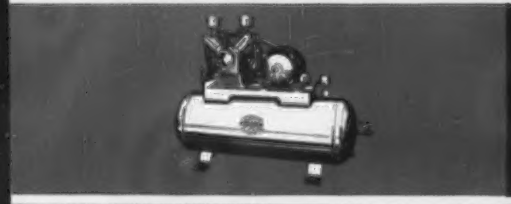

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tooling with optics

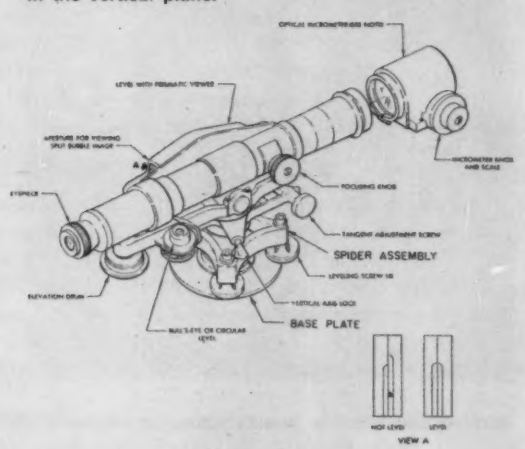
line of sight instruments build three dimensional reference lines in space for aligning jigs and fixtures

by S. Peter Kaprielyan

Networks of invisible lines are being used to provide aircraft and missiles with precise geometries. This has come about by cross-breeding optical science with tooling techniques. The reliability of the resulting three-dimensional control is based on the premise that light normally travels in a straight line.

In tooling, accuracy of fixtures depends upon the precise relationship of reference points, lines, angles, and planes. An increasing number of optical devices are being used for such purposes. Among some of the widely used devices are the alignment telescope, the transit, the sight level, the optical square, and the collimator. Optical polygons or special mirrors, and targets are additional useful accessories.

The sight level incorporates a telescope, a prismatic viewer, an optical micrometer, and a bull's-eye level. Optical micrometer (shown detached for clarity) is clamped on objective end of telescope, and positioned to measure displacement in the vertical plane.



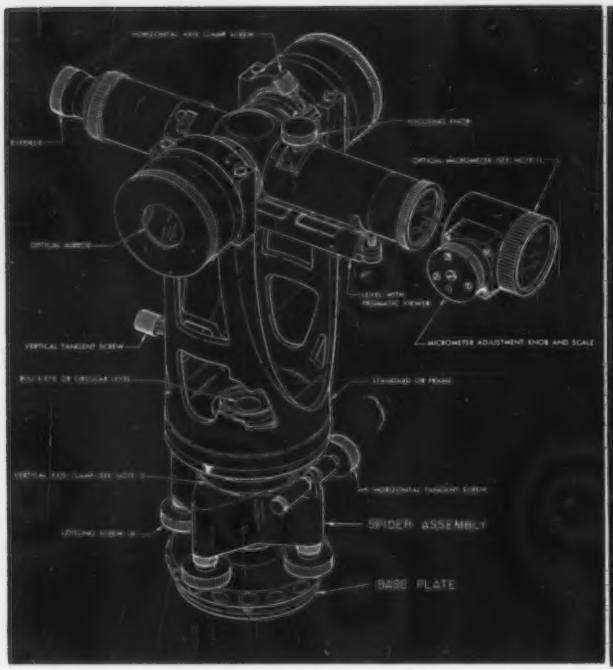
Circle 27 on Inquiry Card, page 81

Alignment Telescope

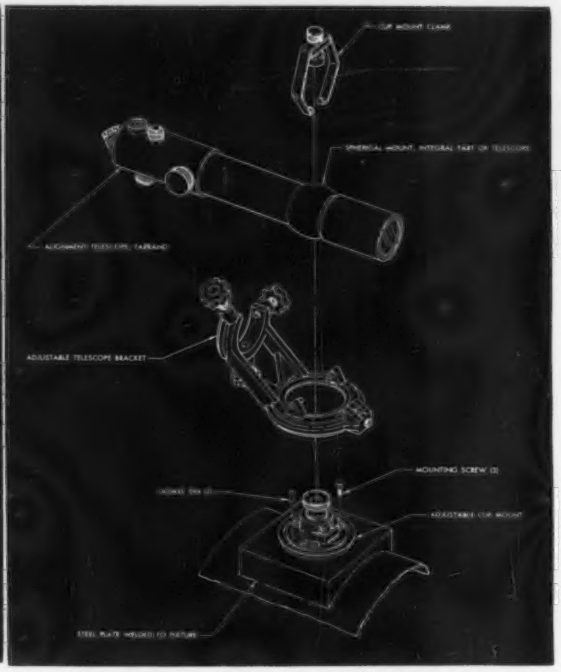
This is the basic instrument which is used with a target to establish reference lines-of-sight. This telescope contains cross hairs in its optical axis; the optical axis is identical with the mechanical axis. Alignment telescope power presently ranges from 30 to 60; vertical or horizontal displacement from the telescope line-of-sight may be measured by built-in optical micrometers. Two distant alignment telescopes may also be used to provide a line-of-sight. Basic step in building a three-dimensional grid system in space is to set a master line-of-sight. The master line-of-sight is also called remote line-of-sight because it is physically removed from tooling fixtures; that is, two alignment telescopes, or a telescope and a mirror, are supported on separate stands.

Positioning of a tooling bar follows the establishment of a master line-of-sight. The tooling bar is a rigid stabilized, beam-type stand fixed in a parallel relationship to the master line-of-sight. The tooling bar usually provides a slide for mounting squaring instruments; indexing holes may also be provided on this bar to locate successive vertical plane stations. Since lines-of-sight on fixture are parallel to tooling bar, vertical plane stations are also related 90 deg to fixture lines-of-sight.

continued on next page



The jig transit is shown with optical micrometer which is clamp mounted on the objective end of telescope, and may be rotated to measure displacement in the vertical or horizontal plane, as needed.



Exploded view shows mounting of alignment telescope on tooling fixture.

tooling with optics . . . continued

Jig Transit

The jig transit is used to erect vertical planes. The transit can also establish lines perpendicular to a horizontal plane. This instrument is similar to surveyor's transit. The telescope of the transit is mounted near its center of balance in a frame to allow plunging through a 360 deg vertical arc. The frame is mounted on a spider and bottom plate, with bushings or bearings which allow 360 deg rotation horizontally. A bull's-eye, or circular level is mounted in base of telescope frame for rough leveling of transit. A more precise level, with a prismatic viewer having a split bubble image is located on telescope tube. An optical micrometer is mounted on objective end of scope. Also, optical mirrors are incorporated on either side of telescope trunion axis. These mirrors are mounted vertically, parallel to the sighting axis of the telescope and serve for auto-collimation.

Auto-Collimator

This instrument functions somewhat like a micro-alignment telescope. It serves to establish 90 deg angles by reflecting into a mirror a target image placed at the objective lens of its telescope. Such a telescope has its own light source; a perfectly centered image indicates that target is truly square as related to telescope sighting axis.

Auto-collimators have also been used indirectly to extend the accuracy of tooling fixtures. This has been accomplished by making surface plates truly flat for supporting various fixtures and gages used in tooling.

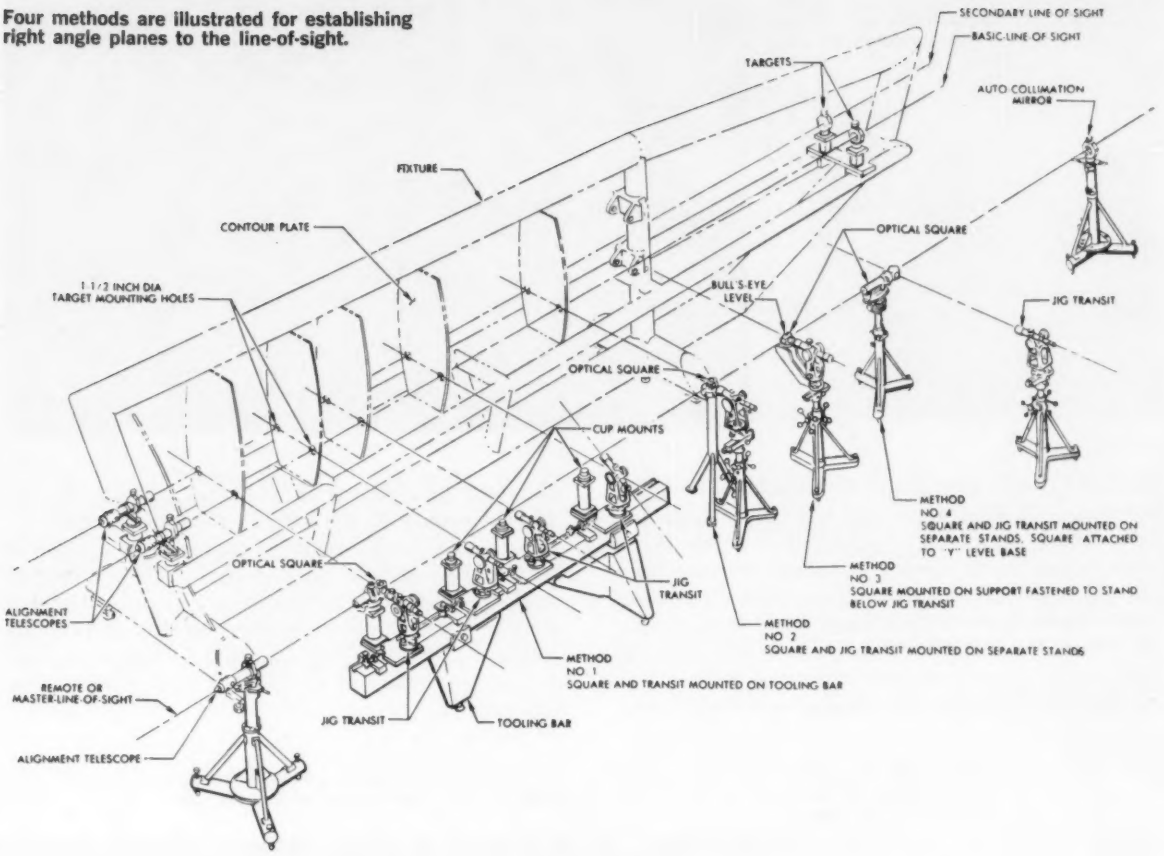
Sight Level

This is a prismatic viewing type of spirit level, attached parallel to optical axis of a telescope. A split-bubble image and a micrometer are also provided here, as on the transit. These two refinements make it possible to set level points on a horizontal plane to close tolerances. The sight level can also measure or set vertical distance between two horizontal planes or points.

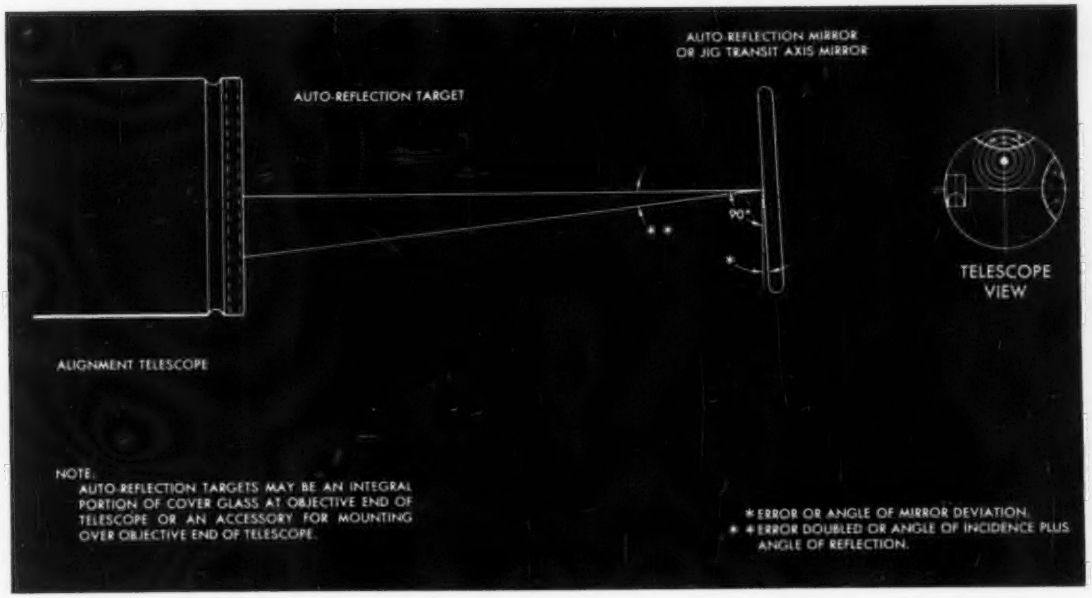
Optical Square

The optical square is a system of two mirrors in a five-sided-prism relationship. Its frame is provided with a large bore for mounting over the objective end of the alignment telescope. The optical square provides a means of sighting targets at 90 deg to a basic line-of-sight. This device may be attached to an adapter and mounted on a

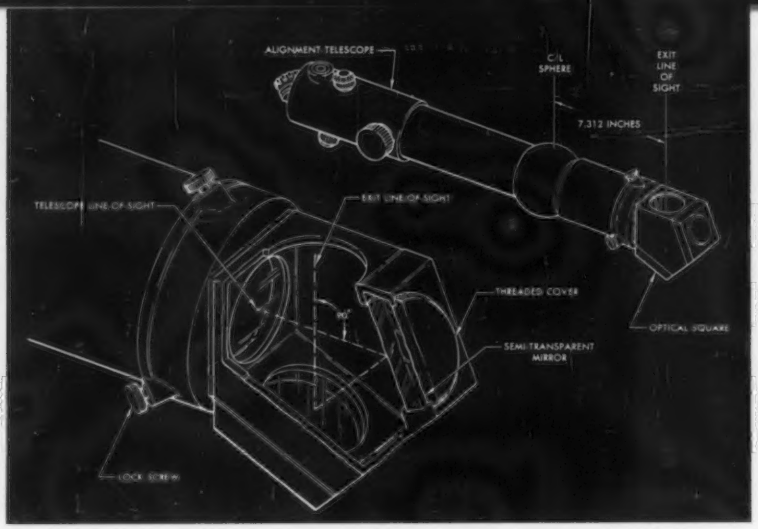
Four methods are illustrated for establishing right angle planes to the line-of-sight.


SECONDARY LINE OF SIGHT
BASIC LINE OF SIGHT
TARGETS
AUTO COLLIMATION MIRROR
FIXTURE
CONTOUR PLATE
OPTICAL SQUARE
1 1/2 INCH DIA TARGET MOUNTING HOLES
BULL'S-EYE LEVEL
JIG TRANSIT
OPTICAL SQUARE
CUP MOUNTS
METHOD NO 4 SQUARE AND JIG TRANSIT MOUNTED ON SEPARATE STANDS, SQUARE ATTACHED TO "V" LEVEL BASE
METHOD NO 3 SQUARE MOUNTED ON SUPPORT FASTENED TO STAND BELOW JIG TRANSIT
OPTICAL SQUARE
JIG TRANSIT
ALIGNMENT TELESCOPES
METHOD NO 2 SQUARE AND JIG TRANSIT MOUNTED ON SEPARATE STANDS
METHOD NO 1 SQUARE AND TRANSIT MOUNTED ON TOOLING BAR
REMOTE OR MASTER-LINE-OF-SIGHT
JIG TRANSIT
TOOLING BAR
ALIGNMENT TELESCOPE

Process of checking 90 deg angles to the line-of-sight by using a mirror to reflect image of target. The target is placed at the objective lens of telescope.


AUTO-REFLECTION MIRROR OR JIG TRANSIT AXIS MIRROR
AUTO-REFLECTION TARGET
90°
* *
*
TELESCOPE VIEW
ALIGNMENT TELESCOPE
NOTE:
AUTO-REFLECTION TARGETS MAY BE AN INTEGRAL PORTION OF COVER GLASS AT OBJECTIVE END OF TELESCOPE OR AN ACCESSORY FOR MOUNTING OVER OBJECTIVE END OF TELESCOPE.
* ERROR OR ANGLE OF MIRROR DEVIATION.
* * ERROR DOUBLED OR ANGLE OF INCIDENCE PLUS ANGLE OF REFLECTION.

Optical square cutaway reveals how line-of-sight is deflected 90 deg.

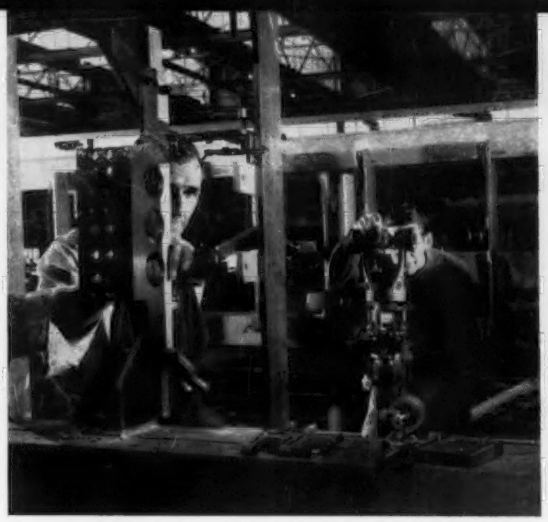


tooling with optics . . . continued

separate instrument stand at a distance from the telescope. A separate stand will allow square to be moved to any point along a line-of-sight; it can thus be applied to a control system of linear measurement with the tooling bar. The jig transit may also be fixed at right angles to a line-of-sight at any linear station. This is done by mounting the optical square in the sighting axis of the alignment telescope and collimating; that is, collimating by sighting through jig transit and the optical square to the infinity-focused telescope.

Two optical squares may also be combined to establish parallel lines-of-sight. The number of useful ways an optical square or any optical device may be used is only limited by the skill and imagination of the user. Typical applications of optical tooling instruments are shown in accompanying illustrations.

Convair 880 jet airliner wing-fixtures are seen here being aligned by an optical telescope. Line drawing at the right shows typical instrument stand with cross slide used for supporting telescope.

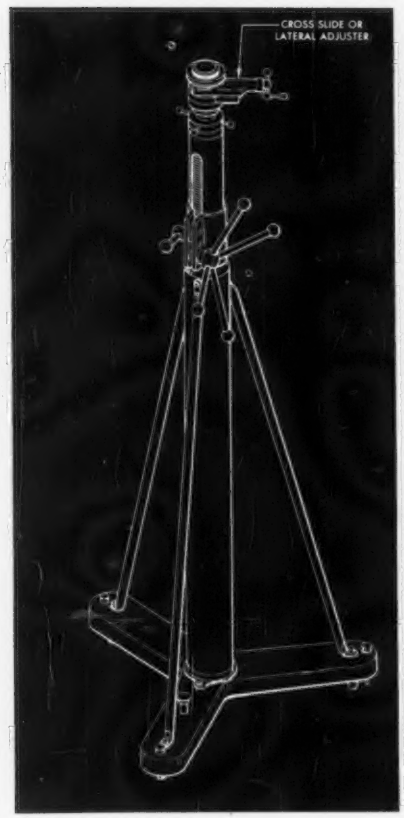


Jig transit on separate stand is being used to check reference point on vertical fixture. Tooling mechanic at left holds drop light to illuminate work area.

Among the category of numerous accessories to optical tooling, mirrors of many types are being put to specialized uses. Optical polygons are now available ranging from a few faces upwards. Optical polygons are especially useful in missile manufacture where circular spacing is encountered.

Closed-Circuit Television

The application of closed-circuit television to optical tooling has increased the accuracy and the speed of sighting procedure. The camera is positioned to look into the eyepiece of the telescope, like a human observer would; the image seen by the camera is translated to the screen of the receiver set. The observed image is thus magnified several-hundred times, and is plainly visible to tooling personnel about the fixture. Thus, even a single operator can attend to alignment procedure by observing the results of his adjustments on the large screen.



Tooling mechanics shown establishing station planes on a Convair 880 wing fixture. Jig transit at left is located on a tooling bar.

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This article is based on material furnished by Convair, a division of General Dynamics Corp., San Diego; and American Society of Tool Engineers technical paper No. 160.

role of optics in Snark

guidance system poses new fabrication problems, Northrop uses own development lab to meet challenge

by Paul H. Halderman, supervisor optical devel., Nortronics Div.,
A. S. Turner, asst. chief tool engineer, Northrop Div.,
Northrop Aircraft, Inc.

As the clothes of a man reveal little to the psychologist, the outer shell of the SM-62 Snark reveals little of special interest to the optical engineer, and the tool engineer. It is the mind of the man, and the "mind," or guidance section, of the missile which respectively present the challenge. This section of Snark contains components which require tolerances so low as to defy conventional machining techniques; tolerances so low as to defy conventional inspection techniques.

Northrop Aircraft, Inc. recognized these approaching problems as early as 1949, and established an Optical Development Laboratory as an integral part of the Engineering Dept. It had become apparent that the best way to meet certain of the demands in the SM-62 project was through optics, and the best way to obtain quality in the special optics required was to establish an R&D laboratory capable of design, fabrication, and certification close to the project.

Worm and Sector Gears

Optics have played an important part in the fabrication and certification of worm and sector gears on the intercontinental Snark.

A Twyman-Green Interferometer, in which the working arm mirror follows the thread of the screw and advances along the optical axis, has been useful in the calibration of the lead screws. Repeatability in the order of 3×10^{-6} in. over 0.3 in. has been obtained with an electronic fringe shift counter.

Sector gears, accurate to 5.0 sec of arc from tooth to tooth non-cumulative over 54 teeth, are produced by using an optical-measuring, manual-indexing method for positioning the gear blank before each cut is made. Thus, instead of moving the gear sector in geared relationship with the hob, the gear sector is optically positioned and firmly fixed during the generation of each full tooth. The generation of the teeth is accomplished by a lead screw which moves the hob tangential to the gear sector pitch diam. Upon completion to tooth depth, the gear sector is repositioned by optical means for the next series of passes. This operation is continued until all teeth have been completed.

The primary and secondary optical systems employed for positioning have permitted accuracies to 0.1 of one second of arc.

In developing a machine to do this job, master angle blocks and transmission wedges

Northrop SM-62 Snark begins 5000 mi flight with rocket boosters and J-57 gas turbine blazing. Both high-speed airframe and guidance were developed by Northrop. Optics played a major role.

were used to lay off the relatively large angles for gear-tooth increments. A microptic autocollimator was used to pick up a reflection off the face of the blocks after they were placed against accurately ground and lapped pins on a support table. (See illustration.) The table was rigidly attached to the gear. A 90 deg sector was covered with the use of seven glass angle blocks, one plane parallel and two refracting wedges. These could be oriented so their deviation would add or subtract to optically build up the required angle. The wringing errors of metal angle blocks were thus eliminated and a significant reduction was obtained in the time required to produce a precision gear.

A typical production gear hobbing machine which was an outgrowth of this program is illustrated. A granite foundation is used to make the machine virtually vibration free. The optical indexing employed utilizes the matching of fringe patterns in a split field Twyman-Green interferometer. All that is required is a careful fringe count.

Gear Inspection

Optical principles were found necessary to accurately check the results of the gear-cutting equipment.

A check fixture was developed utilizing mirrored-surface type optical reflecting units. The reflectors are mounted in an established relationship with a spindle assembly to which the gear sector is attached. By rotating the gear an amount exactly equal to the angular spacing of one gear tooth, the reflector is rotated the same angular amount. Using an integrally mounted angle Dekkor type autocollimator, any deviation in the required angular measurement can be checked to the nearest half of one second.

In addition to the basic primary reflector, there is a secondary reflector, and a referencing index reflector.

Optical Polishing

Another example of low tolerance requirements is in a 17-7 PH stainless steel plate used as a master surface. The part has a specified flatness in the center reference area of ½ fringe. Such results are obtained only by optical polishing, a series of tedious grinding and lapping operations. A 22 per cent reflectivity is presently being produced on the stainless parts. The surface is polished flat while holding parallelism to less than 3 sec of arc on the three reference pads.

Inspection of the result is performed by measuring the reflectivity of the surface. A minimum reflection of 10 per cent of the introduced tungsten light filtered through a number 57 wratten filter and measured 15 min (± 5 min) from normal to the reference plane is required for acceptance.

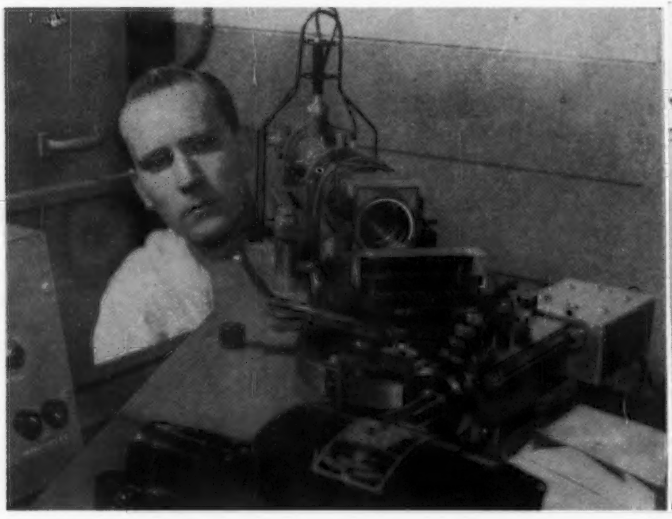
Optics in Milling and Boring

An intricate 356-T61 aluminum sand casting serves as an instrument platform in the Snark guidance section. This part requires difficult milling and boring operations within ± 30 sec angular limits.

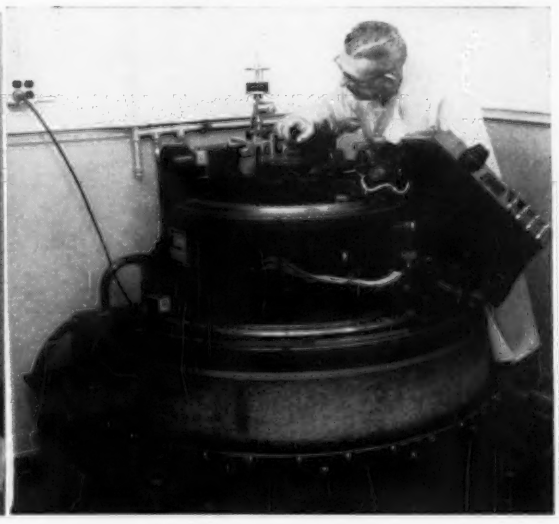
Casting is rough machined to remove 0.045 in., solution heat treated and aged. Semi-finish machining removes another 0.060 in., and similar heat treating follows. Finish machining removes the final 0.020 in.

continued on next page

Optics Development Lab designed experimental gear hobbing machine. Microptic autocollimator is used to pick up reflection from master angle blocks and transmission wedges.



Production version of gear generation machine is mounted on granite to virtually eliminate vibration. Optically-measured, manual-indexing is used.



optics in the Snark . . .

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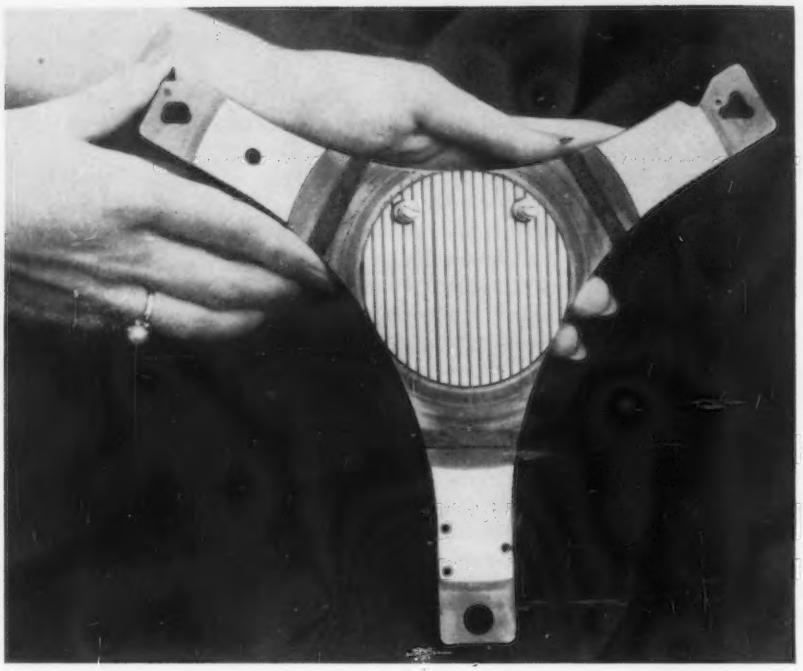
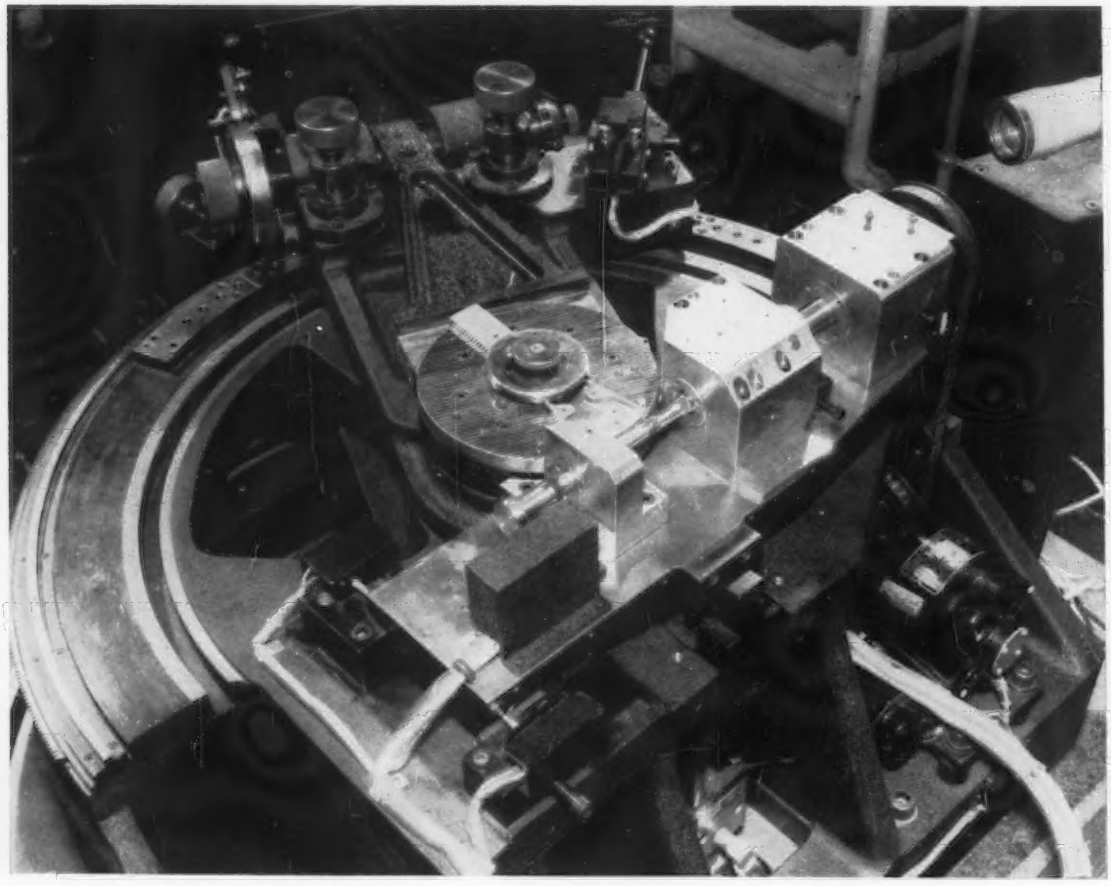


Optical polishing was necessary to achieve the required flatness on 17-7 PH stainless master surface. Optics are used to check finished surface reflectivity.

Close-up of working table shows gear sector mounted on center pad. Lead screw moves hob tangential to pitch diam. 5.0 sec of arc tolerance, non-cumulative over 54 teeth is allowed.



Special high speed milling and boring machines are used to achieve finished accuracy. Angular indexing to preset stations is accomplished by optical dividing heads.

As Good as the Glass

The optical instruments and optical methods used in production are certainly only as good as the quality of the lenses and prisms which comprise them. Northrop's Optical Development Lab has had the challenging task of developing many of the basic optics involved in Snark production, and has the continuing challenge of maintaining and improving these standards.

Perhaps the most precise of the optics, however, are not ground-bound. They are an integral part of the navigation system by which Snark finds its way to a target 5000 mi distant.

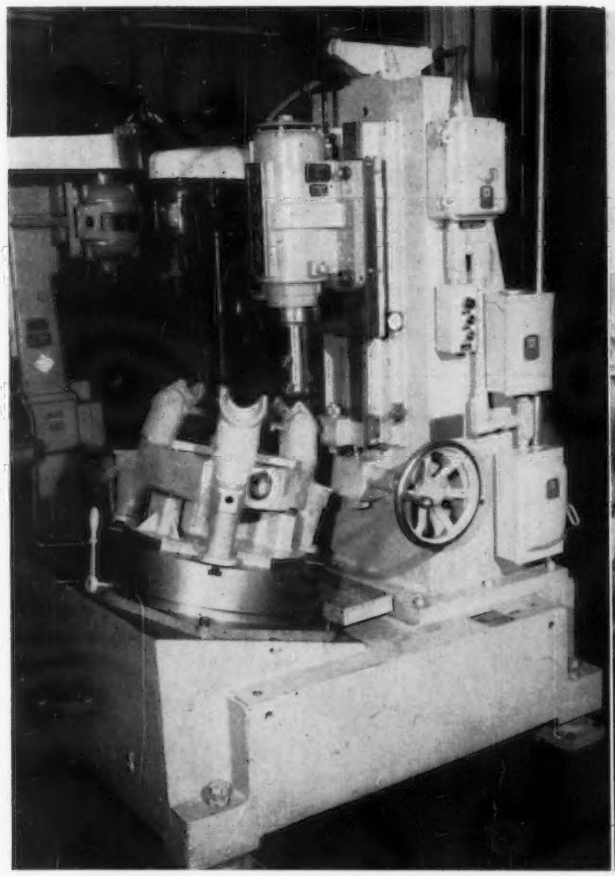
The sextant window presented problems in fabrication and measurement. Many of the instruments and machines used in these steps came into being because no existing hardware could perform the specialized tasks.

A universal surface generator was designed for window generation. Two special instruments were designed and built to measure the index change in the window and the three sec of arc wedge-tolerance.

In addition to homogeneity, flatness, and wedge specifications, the window required a nonreflecting coating on both surfaces. The transmission of this vacuum deposited coating was maximized for transmitted energy, and minimized for varying incidence angles from 0 to 60 deg. A prescription of a multiple coat of titanium dioxide and magnesium fluoride was obtained from the IBM 704. Application technique was perfected for uniformity and durability in the laboratory.

The efficiency of the first surfaced mirrors in the navigational system was also improved as a result of an R&D program. Functional requirements of the mirrors included angles of incidence of 0 to 50 deg and wave lengths of 4000 to 7000 Angstroms. After a prescription was obtained from the IBM 704, an electronic monitor was designed and built so the precise film thicknesses could be detected independent of the insensitivity

Special high-speed milling and boring machines (Pope Machinery Corp.) were designed for instrument platform in guidance section. Optical dividing heads are used for angular indexing to ±30 sec.



Airborne optics require great specialization. Machines like this universal surface generator were developed for navigational sectant window.

optics in Snark . . . continued

of the human eye. Reflectivity in excess of 96 per cent is obtained at a 45 deg incidence angle between 3800 and 4800 Angstroms. The durability of the coat has been improved by a factor of 6.6 times as a result of R&D.

Small Apertures

A problem of fabricating small apertures arose from the requirements for a field stop. A 0.0790 in. (+0.0000, —0.0002 in.) and a 0.0040 in. (±0.0001 in.) aperture were required in the field stop assembly. A vacuum evaporation technique was developed in which a tapered pin with a flattened end was used to mask the circular area where the aperture was desired. By means of a jig, this pin was placed almost in contact with the surface of the glass cylinder and the aluminum was evaporated from multiple sources to coat the flat. Since the end of the pin acted as a mask, sharp uniform apertures were obtained.

Sextant Alignment

In addition to the systems optics, there were many problems in sextant alignment and certification. Master 60 deg polygons and cubes were fabricated to define 3 lines of sight in planes 120 deg with respect to each other and three planes 90 deg with respect to each other. These prisms are certified to less than one sec of arc with a one sigma limit of 0.2 sec. Perfect circle methods are used on a one second spectrometer.

An azmuth calibrator and star simulator was designed and built utilizing artificial backgrounds and signals. Optical trains were used to place these signals in the desired relation to each other and to a common reference plane and at the desired location in space, i.e. infinity. Master prism assemblies are used to calibrate this instrument. Four lines of sight are defined, one line of sight normal to the base and three lines of sight 45 deg with respect to the normal and 120 deg with respect to each other. Such prism assemblies are a challenge because of the tolerances of one or two seconds on the lines of sight and due to the fact that the three prisms are optically contacted with a tolerance of 1/16 in. on radial position with respect to the center of the base. Optical contacting was used because of the stability of the assembled components. Cement is not used in optical contacting, adhesion is the result of molecular attraction of matching surfaces.

Impact

The challenges revealed by Snark, and its contemporaries, are an indicator to the future. It is inevitable that tolerances and finishes will become more and more exacting. It is inevitable too that the more precise methods now relegated to the laboratory will be forced into the production line.

The use of optics will increase to the point of becoming almost routine. To keep pace with demands machine tools will have to undergo a complete revolution in design.

Precision will soon be measured in millionths. When one stops to reflect that such tolerances encroach upon the measurement perimeters of our own Bureau of Standards, it is interesting to speculate what will happen next.

◆

Portions of this article contributed by Mr. Turner were extracted from paper 157, American Society of Tool Engineers.

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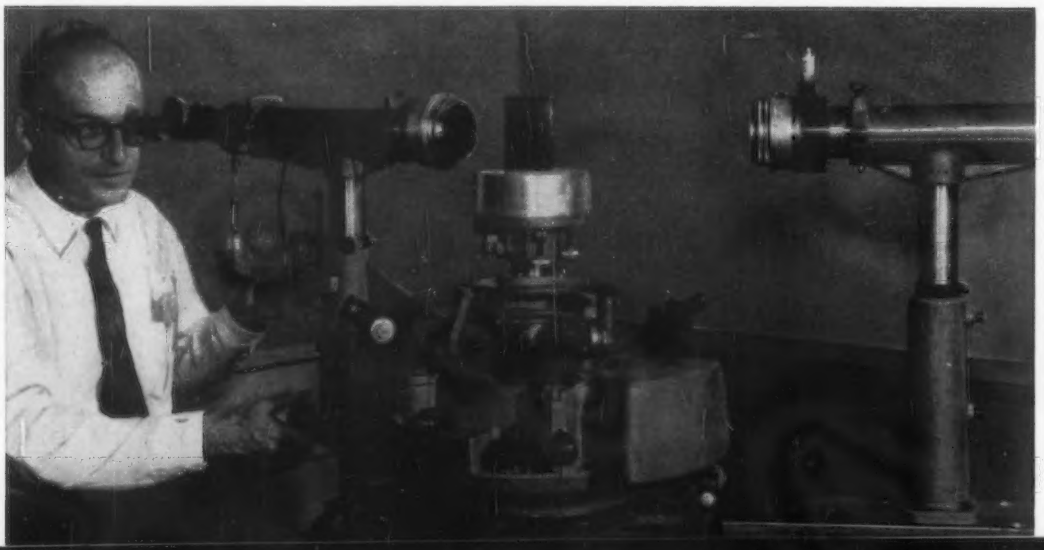
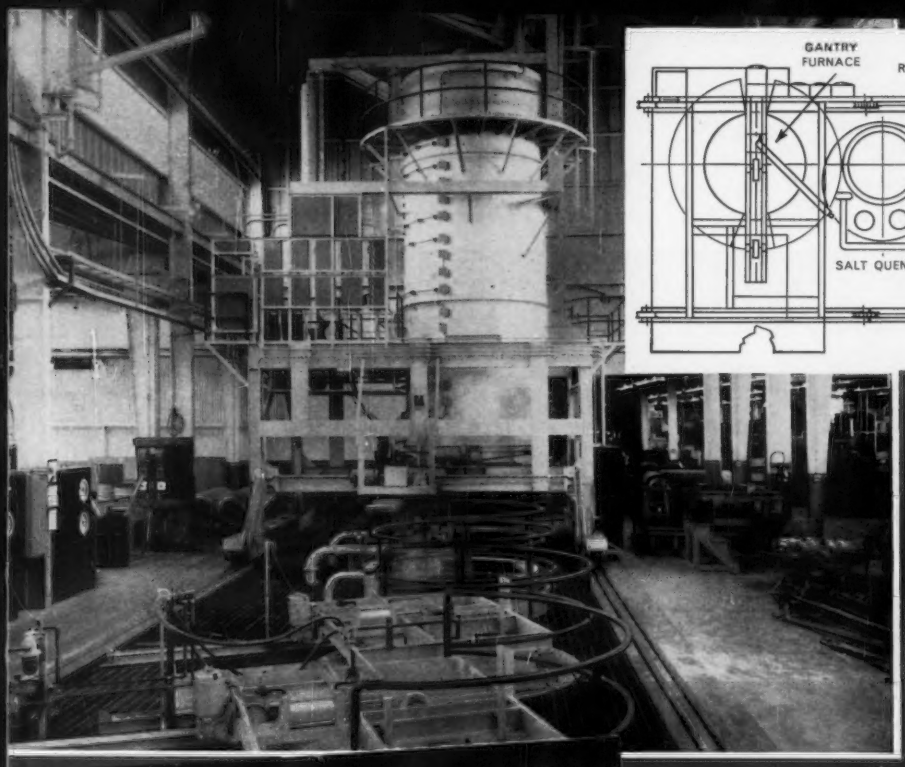
Prisms for guidance system are certified on one second spectrometer like one shown. Perfect circle methods are used.





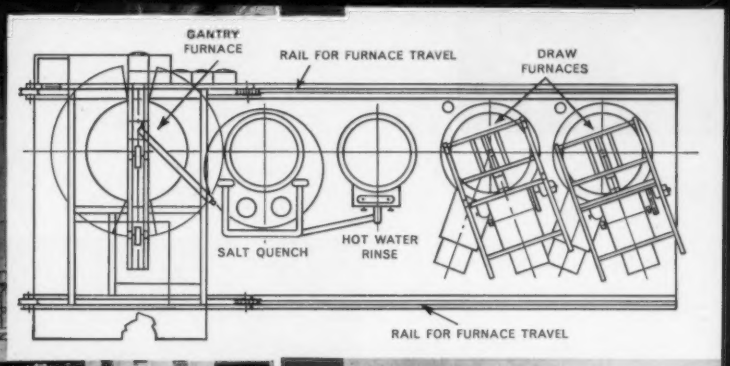
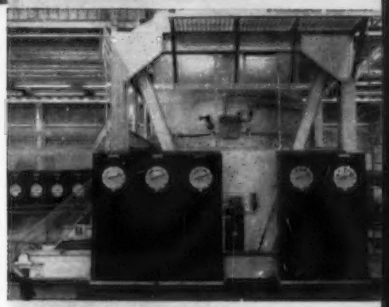


Diagram shows efficient grouping of all elements of the installation.

Lindberg-Designed

Furnace is more than 24 feet high. Chain shown at right lifts work into furnace.

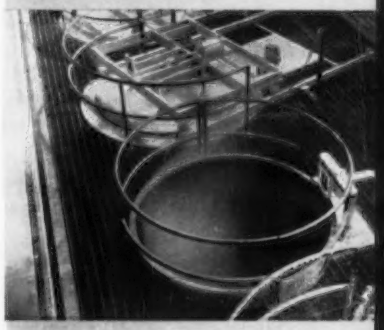
The World's Largest Vertical Controlled-Atmosphere Drop Bottom Hardening Furnace



Lindberg control panels are conveniently located adjacent to the installation.

This remarkable furnace combination was recently installed by Lindberg Industrial Corporation for a prominent missile manufacturer. It was designed by Lindberg engineers, in cooperation with the engineering staff of the manufacturer. The furnace is more than 24 feet high and is capable of heat treating rocket cases more than 5 feet in diameter and 20 feet long. The installation consists of the electric, controlled-atmosphere, Gantry type furnace and two draw furnaces, a hot water wash tank, a salt bath quench and a high nitrogen generator. The Gantry type furnace moves under power over the entire installation to load or unload at any of the pit stations. With this installation, production has been economized and speeded, and the metallurgical qualities of rocket cases improved.

Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, heat treating, melting and holding, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg Industrial Corporation, 2321 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.



Pit has depth of more than 20 feet to accommodate large rocket cases.

heat for industry

Circle 28 on Inquiry Card, page 81

optics in quality control

compressor-vane airfoil on J-75, J-52 checked with contour projector by Thompson Products; Stratos uses variation for precision gears

Special inspection precautions are necessary in precision grinding operations like those required on modern jet engine compressor vanes.

On each job, it has turned out, there are new quality control problems. New techniques and equipment are needed to meet these problems.

One such job currently running through Thompson Products' Tapco plant offers a good example. Thompson is supplying stators for the Pratt and Whitney J-75 and J-52 compressor sections. The J-75 and J-52 subcontracts were large enough in scope to make it profitable for Thompson to set up a special line for the grinding of vanes.

In routine operation, craftsmen on this line make 10 to 12 new working setups per day. The average job runs three days or better. Vanes come through this grinding line directly from the forges. Grinding tolerances which must be applied on these jobs would have been considered virtually impossible just a few years ago considering the volume of blades involved. A few tolerance examples: on the critical lugs, band tolerances are $\pm$ 0.0015 in.; displacement contour must be within $\pm$ 0.003 in.

In essence, grinders on the J-75 and J-52 vane lines must work on a part which has an airfoil shape, maintaining tolerances which would be considered good for a part with straight edges.

The critical measurement on the vanes is the contour of the tips. These must be measured in relation to a position corresponding with a hypothetical center-of-gravity. The problem was approached by designing special fixtures to position the vanes on optical contour projectors. Reason for choosing these optical gaging instruments was that they provide an adequately bright and dependably accurate means of measuring to prescribed tolerances through the use of surface illumination. What Thompson was after in this

In-plant inspection of precision helical gears for a liquid and gas compressor is accomplished with a contour projector. Magnification is about 50 times. Quality control using optical device is effective.

case was a close measure of the shape of the end of the vane lug as it comes from its most critical grinding operation.

To check out a ground part, the grinder takes the special staging device and a sample part to the contour projector.

A chart-gage especially designed for measuring this particular vane is fixed over the viewing screen of the contour projector. Then, a special positioning fixture is placed in a pre-determined position and checked against the chart-gage using conventional, shadow illumination. Depending on the size of the vane, either 10x or 20x magnification is used. The operator can obtain the desired magnification by merely flicking a control switch. Precision lenses in the projector's rotating turret click into position automatically.

The operator positions the work stage of the contour projector for gaging of the part in hand. The outline of this positioning device is matched into specially-ruled spaces on the chart-gage. This operation is also used to set the master for projection gaging.

Then, the actual holding fixture for the vane is placed in a pre-determined position and the vane itself is pressed against its positioning pins. The surface illumination of the contour projector is turned on. By matching the projected image of the face of the lug, with the lines of the ruled chart-gage mounted over the viewing screen of the projector, the operator can tell quickly whether his job fits its specifications.

The contour projector checking operation is repeated for several pieces before a job is put on a production basis. Each piece off the grinder is checked on conventional pressure and envelope gages. But, because the steel is so hard and the tolerances are so close, the operator will be back at the contour projector frequently during the course of production run.

Depending on what part is being ground and which machine is in use, an operator may check out every fifth piece on the contour projector. At very minimum, every twentieth piece is checked out completely on the optical comparator.

Painstaking, yes; but the accuracy is very necessary and the method is very effective.

Stratos "Worm Gears"

Two gears which mesh within a split thousandth but do not touch each other require the greatest precision through every phase of manufacture and inspection.

This in essence is the Stratos compressor, called Heli-Rotor. The two gears, which look like "worm gears" but definitely are not, mesh so precisely that gases or liquids passing through are actually compressed. The only place at which the gears touch is at a small area near the power source which drives them.

Testing whether this precision has been met in each gear is handled by the inspection operations department at Stratos with a contour projector. Optical Gaging Products and Eastman Kodak jointly developed a special staging fixture, which allows an image of the helical rotor to be projected on a screen and compared with a precise design drawing. Magnification is in the order of 50 times. This optical inspection fixture has proven an effective and adequate quality control tool.

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hands across the drawing board

design and production missile engineers take a serious look at each other's problems, decide the problems are mutual and can be solved best by cooperative effort

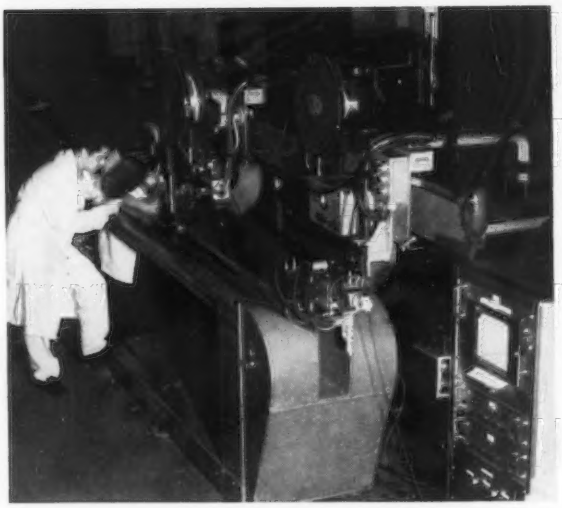
by John P. Kushnerick

The prodigious growth of guided missiles has caused unprecedented manufacturing problems, both technical and administrative. Many organizations learned early, others are still learning to their own detriment, that teamwork between design engineers and production engineers is a mandate to coping with these problems. Feedback from developmental engineers completes the circuit; but design and production must cooperatively know what to do with the information that development funnels back to the factory.

Design Engineering has become known as the "what" department, Production Engineering as the "how" department, and Production Control as the "when" department. Without the proper interchange of information some organizations have put the "how" department in the middle of a dilemma. They have been told "when" to build, but cannot determine "how," because the complete details on "what" are not in their grasp. This is probably the most frequent and troublesome situation. But it is being handled by slow individual realization that no man, no section, no department, and no company is an island.

Production Engineer Speaks

Without flouting their success, and they have had considerable with the Redstone-Jupiter line, production engineers at Chrysler Corp. point out specific problems and how they were solved.



Welding fixture was developed through design and production cooperation. Incorporates a 72-in. horizontal working length. Close-butted copper fingers extend this full length and hold work in place.

The premise is that missile production engineer must use techniques not yet developed, must work with new equipment and materials just being explored, and must think in terms of quality and reliability one order greater than he accustomed himself to in aircraft.

Lack of specific engineering definition in time to meet delivery schedules could be con-

Army Jupiter presented many new welding problems for Chrysler Corp. Two-phase welding program was initiated with ABMA cooperation, fixtures and techniques were developed.

sidered the most serious problem. The production engineer, however, does not want to discourage design changes, he recognizes these as essential to progress. Neither does he wish to pressure the designer for so much information as to cause design compromise. This defeats his own purpose, since it could result in an unsatisfactory product and expensive rework. Very close cooperation to create a two-way flow of advance information is what he desires.

He must know what the designer is thinking and must be in a position to advise and suggest during preliminary design. He must also have advance information to plan for tools, and develop methods to accomplish the design performance goals within the production control time goals.

Specific Problems

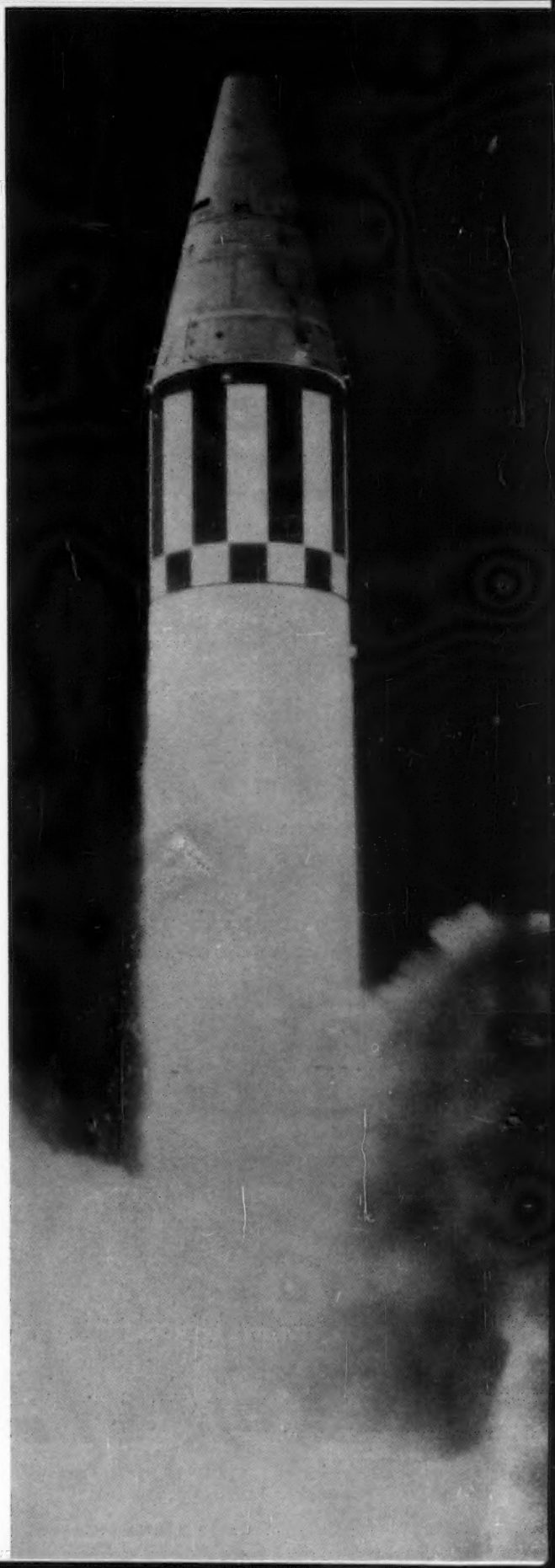
With the extremely large number of soldered wire connections designed into Redstone it soon became apparent that improvements in soldering techniques were required.

Two resistance-type soldering methods were in general use: first, the high-heat, short-time cycle; and second the low-heat, long-time cycle. Production objections were inherent in both methods. The first, while fast, often resulted in melted and distorted wire insulation, and arcing between contact point of terminal and electrode. The second method caused objectionable oxide coatings, and also production slowdowns.

Production Engineering combined the best features of each to come up with a new method. This was accomplished by increasing temperature considerably above that required for soldering for about ½ to 2 sec and then decreasing temperature to just above the liquefication point of the solder. (See Fig. 1.) It was found that a quick, hot temperature for a few sec, followed by enough heat to maintain the molten state provides short soldering cycles, without the inherent disadvantages of high or low heat soldering.

Critical design specification for precise alignment of the various missile sections presented new production problems. After considerable study it was decided to adopt optical tooling.

A typical example of the use of optical equipment is in the alignment of the rocket engine. The purpose of this alignment is to determine the actual thrust angle in relation to a line



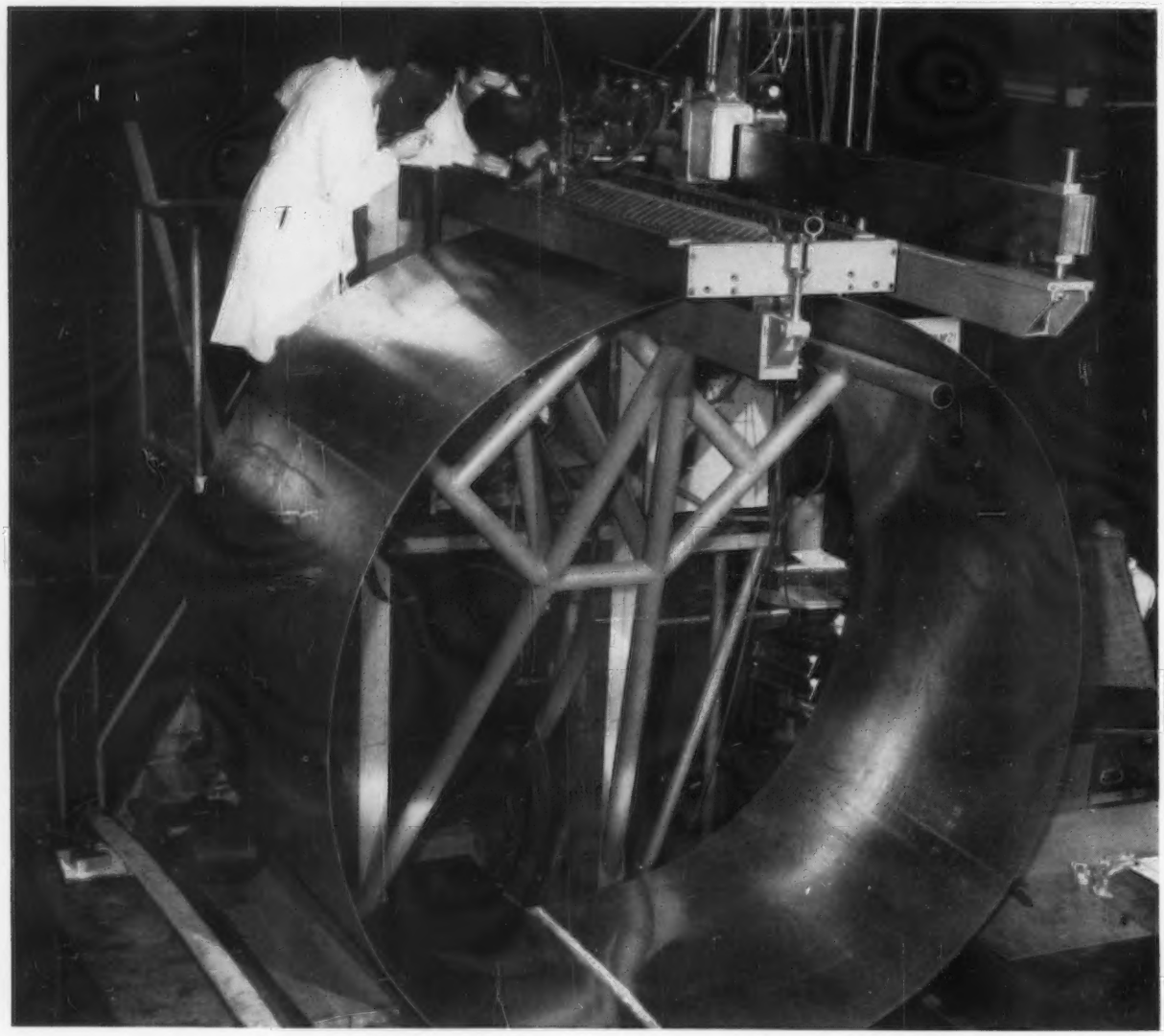
perpendicular to the mounting pads on the geometric center of the missile. The rocket engine is suspended in a horizontal position from a holding fixture. Using an optical transit, the mounting pads are aligned in a perfect vertical plane. At this time, an optical square is established. Utilizing this optical square, a tubular fixture containing a collimator is placed on the theoretical thrust axis. This tubular fixture is also equipped with two dial indicators 24 in. apart. By rotating the fixture and taking readings every 30 deg, enough data is obtained to determine the exact exit and thrust angle. The engine is rotated 180 deg to compensate for any sag and the 30 deg readings are again recorded. The engine is now mounted to the missile center section and another optical check is performed. The fixture is then positioned on the center section centerline and the actual thrust angle and exit displacement are determined in relation to the center section.

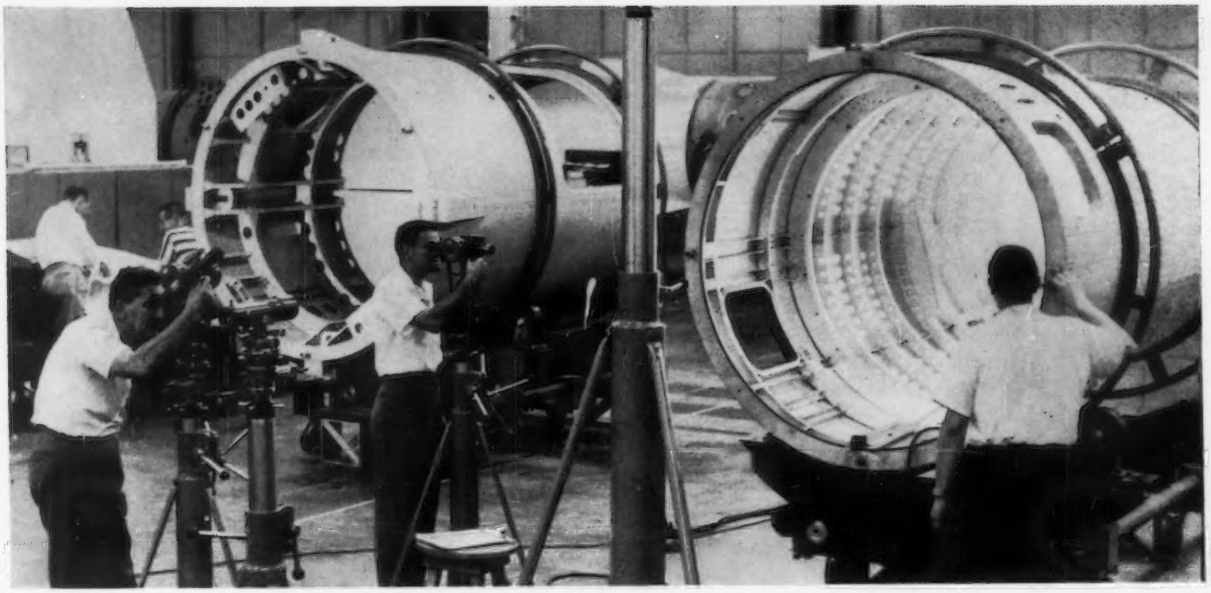
Chrysler and ABMA Cooperation

When prime contract for Jupiter was awarded, many welding problems were encountered because new aluminum alloys had been specified in the design.

The non-heat-treatable alloys gain highest strength through strain hardening. The effect of

Weld fixture in use shows joining of Jupiter shell section. Adjustable air pressure is used to manipulate hold-down fingers. Spacing of fingers is also adjustable for variable quenching styles.





Critical alignment problems were resolved with optical tooling. Rocket engine is positioned on ballistic shell with line of sight instruments.

welding is to anneal back to reduced strengths. The heat treatable alloys gain their strength in heat treatment. The effect of welding is to reduce joint strength even further than the 10-20 per cent reduction experienced in non-heat-treatable alloys.

A welding development program was initiated. It consisted of two phases:

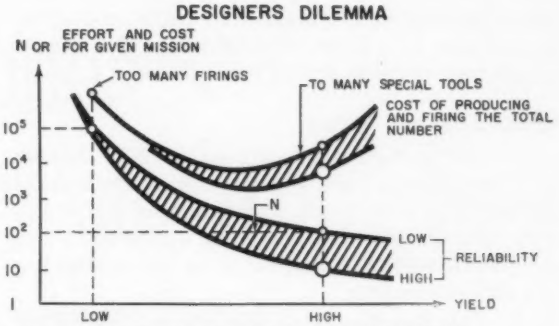
Phase I was a training and organizing phase.

Phase II was work on commercial type equipment.

During Phase I, welding technicians from the producers staff Chrysler) visited with personnel on the designers staff (ABMA) and techniques and methods were developed for welding the Jupiter shell. The welding fixture illustrated was designed, developed, and built by the producer, and controlled welding was begun. Work performed on the fixture provided data on the importance of good hold-down design. Controllable spacing and pressure were determined. Proper back-up material and groove shapes for proper heat penetration and dissipation were ascertained.

Phase II involved controlled welding on high-strength aluminum alloys utilizing new commercial fixtures and designed to incorporate all features that Phase I work indicated were necessary.

The fixture which resulted has a 72 in. horizontal welding capability. Short closely-butted copper fingers extend the length of the weld



Many low yield, simple missiles might originally cost as much as fewer larger, high yield missiles. Handling and firing costs, however, could be excessive. On the other hand, a very few yield missiles could require enough special tools and precision to drive end cost even higher.

area. The hold-down fingers clamp the work by air pressure.

The fixtures mount automatic welding heads for both consumable (Metal-Inert-Gas of "MIG") and nonconsumable (Tungsten-Inert-Gas or "TIG") processes of welding. Various power sources, both ac and dc were used to determine the combination most suitable from both the weld quality and production standpoints.

With properly controlled welding conditions, both MIG and TIG welding of high magnesium content 5086-H34 give comparable quality and strength results. Joint efficiencies are over 90 per cent. Sufficient yield strength and ductibility are obtained, along with soundness of weld

as determined by radiographic and metallurgical tests.

An electronic recorder, to chart exact values of travel, wire feed speed, welding voltage, welding current, and line voltage, was designed and constructed. This recorder is used to establish exact values that are transferable to other production welding equipment.

The Team

Just as increased reliability follows from simple design and construction, so also follows ease of mass production, maintenance and handling. Simple design should, therefore, be kept uppermost in the minds of all designers so that their product can be produced and fired without the use of so many highly trained technicians. Both the Production and Design Engineer can, therefore, do much to facilitate missile production by working as a team to obtain simplification of design and methods wherever possible.

Design Engineer Speaks

The design engineers at ABMA concur that there must be cooperation with production engineers to meet all the expected, and the many, many unexpected manufacturing difficulties. The team-work was first illustrated on the pioneering V-2 ballistic missile.

This missile did not use integral fuel tanks because designers thought it important to insulate the lox tanks from the ballistic shell, and to separate aerodynamic from thermal loads. The use of separate containers complicated design and caused production difficulties. The production engineer justifiably complained. The integral tank-shell was created and proved lighter, more reliable, and simpler to produce. The original, complicated design concept was found to be of little value.

Another example of how a missile profits by teamwork of designer and production engineer is the progressive use of milled sheets, extrusions and tapered beams to fit any complicated stress pattern. These result in a smooth flow of forces and a consequent strength increase with reduction of weight and number of components. Back-up strips, doublers, stiffeners, and many other additional small but extra items are eliminated. This was achieved because the production engineer was aware of the needs of the designer and the designer was willing to mold his ideas to conform with what the production engineer could reliably produce with a consistent quality. This "closed-loop" working arrangement is of increasing importance in the development of large missile systems.

Missile production will be very expensive for a long time to come because missiles require a high degree of part precision and control without the benefit of a large total amount of units which can enhance quality by mass production.

More Manufacturing Research

More manufacturing research is necessary to develop efficient, economical methods. A very general example is the development of joining methods. Bolting and riveting things together is still more reliable than anything else, but actually impairs elegant design. It does not permit minimum weight and is too time consuming in production. Welding, therefore, is practically the only way to join important structural components, especially if pressure tightness is required. But we know that welds of high strength materials are not always very reliable and inspection is not only costly and time-consuming, but in some cases almost impossible. Much can therefore be gained if new methods such as brazing and bonding and, even more important, the old methods of soldering are improved. We have to realize that one broken connection means the failure of a missile. Basic research of all likely soldering materials and alloys is very definitely needed. If bonding agents could be found that stand up well under a wide range of temperatures and are compatible with all kinds of fuels and materials, missile design would profit immensely and new roads would be open for further streamlining and simplification of the fabrication of guided missiles.

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The Editor
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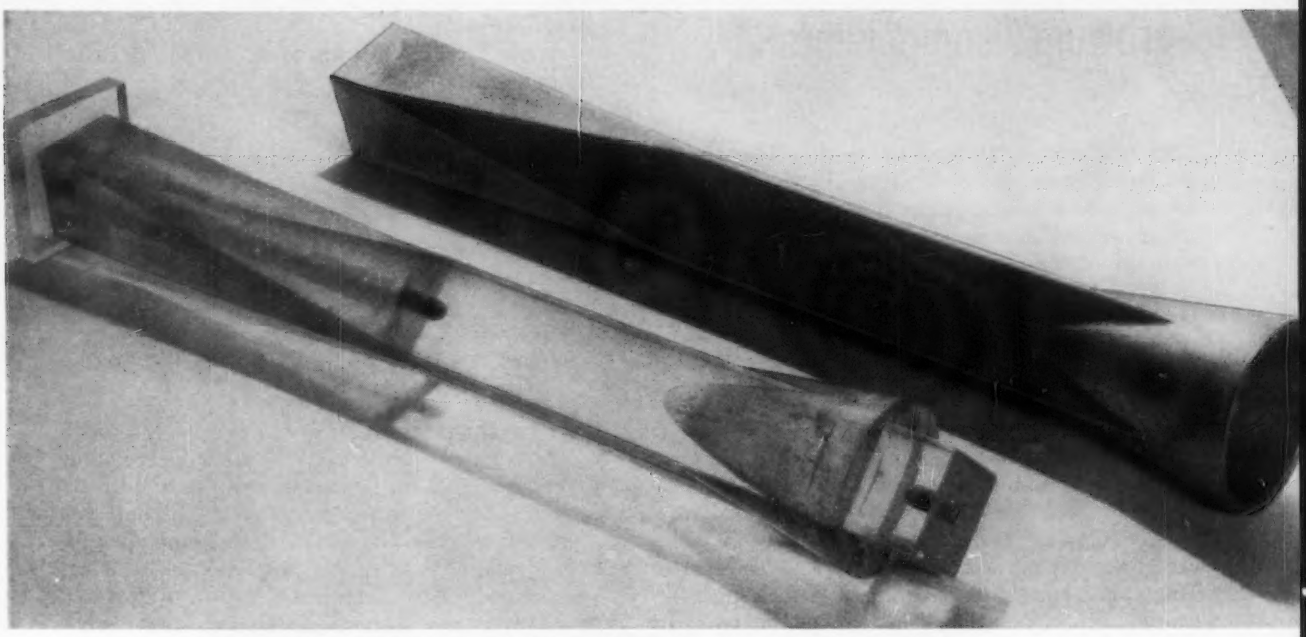
Based on papers presented at 26th annual meeting of the American Society of Tool Engineers. E. A. H. Hellebrand, ABMA, and Frank Swaney, Chrysler Corp., authors.



An example of twisted waveguide tube made on a composite plastic mandrel. Clear right-hand section of the mandrel can be withdrawn and used again, remainder is made of Distrene and is dissolved with trichlorethylene.

"growing" components by electroplating

waveguide tubes generated in complicated shapes, accurate mandrels essential; new class of fine-grain metals seen possible

by Ronald A. Cole

Considerable adoption and development of "growing" components by the electro-deposition process is underway in the United Kingdom. Radar waveguide tubes are an example of the type of part that can be manufactured with this method.

Another aspect of the growing technique concerns the production of items in nickel, copper and lead. These materials gain enhanced mechanical properties during plating. This latter development is perhaps the most important; it gives the designer a whole range of virtually new materials.

Mandrels First

First step toward growing a component is the completion of a mandrel accurately representing the internal dimensions and finish. These are usually made from stainless steel (British Standard S.80), which takes a fine finish and is not easily scratched. Where only small runs are contemplated the mandrels are made of Perspex, a transparent acryl-acetate sheet which is easily worked and polished. In cases where a tube shape prevents the mandrel from being withdrawn after manufacture, a polystyrene plastic is used; this is afterwards dissolved out with a solvent such as

"growing" components . . .

continued

trichlorethylene. Instead of plastic, wax can be employed to reduce costs; this has the added advantage of allowing the mandrels to cast where many expendable molds are needed. A disadvantage of the plastic mandrel is the fact that it is limited to the cooler type of electrolytic bath. On the credit side it has the attraction of lower production cost and lighter weight.

Careful handling of the finished mandrels is essential because any scratch or blemish will be faithfully reproduced on the finished interior. This can best be appreciated from the fact that the tube will maintain the dimensions of the mold to within four ten-millionths in. (0.0000004 in.).

To make plastic mandrels conducting, they are sprayed with a thin coating of silver nitrate. They are then immersed in an acid copper or cyanide copper solution. Most important point in solution selection is the strength of the metal produced; this varies widely with the type of bath. Typical strengths and hardness ranges obtained at the Royal Radar Establishment are given below, together with those for other forms of copper.

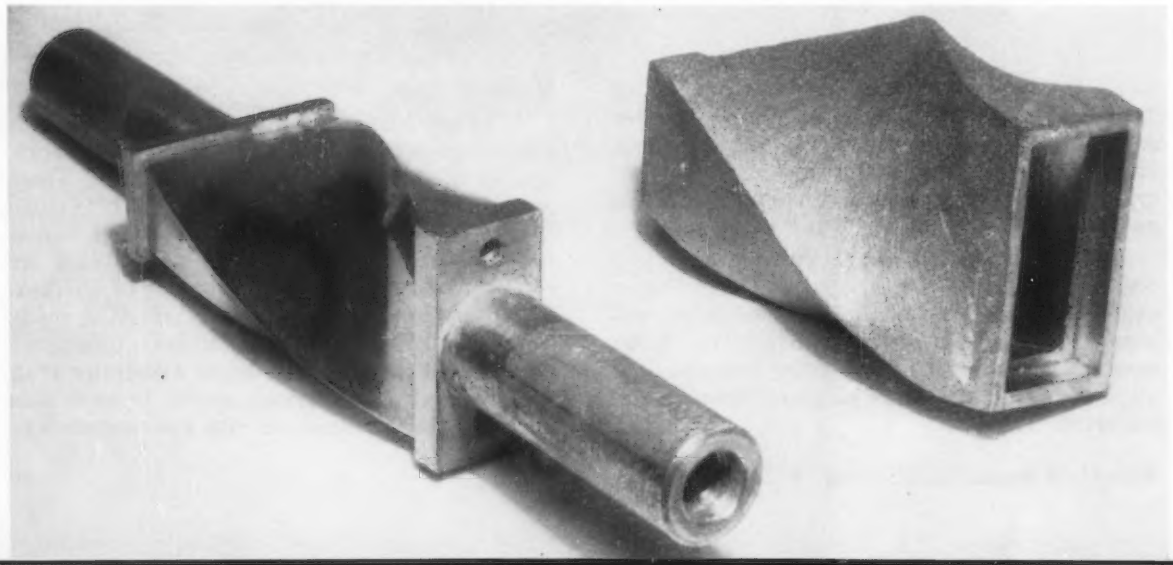
The periodic reversal, or P.R. process, is one wherein the current is passed normally for a few seconds and then reversed in direction for a shorter period, or for the same time at reduced current. This gives a mirror external finish instead of the fine sand grain surface normally obtained. It is not recommended for use on waveguides because of locked in stresses which can give considerable distortion, particularly if subsequent machining is carried out.

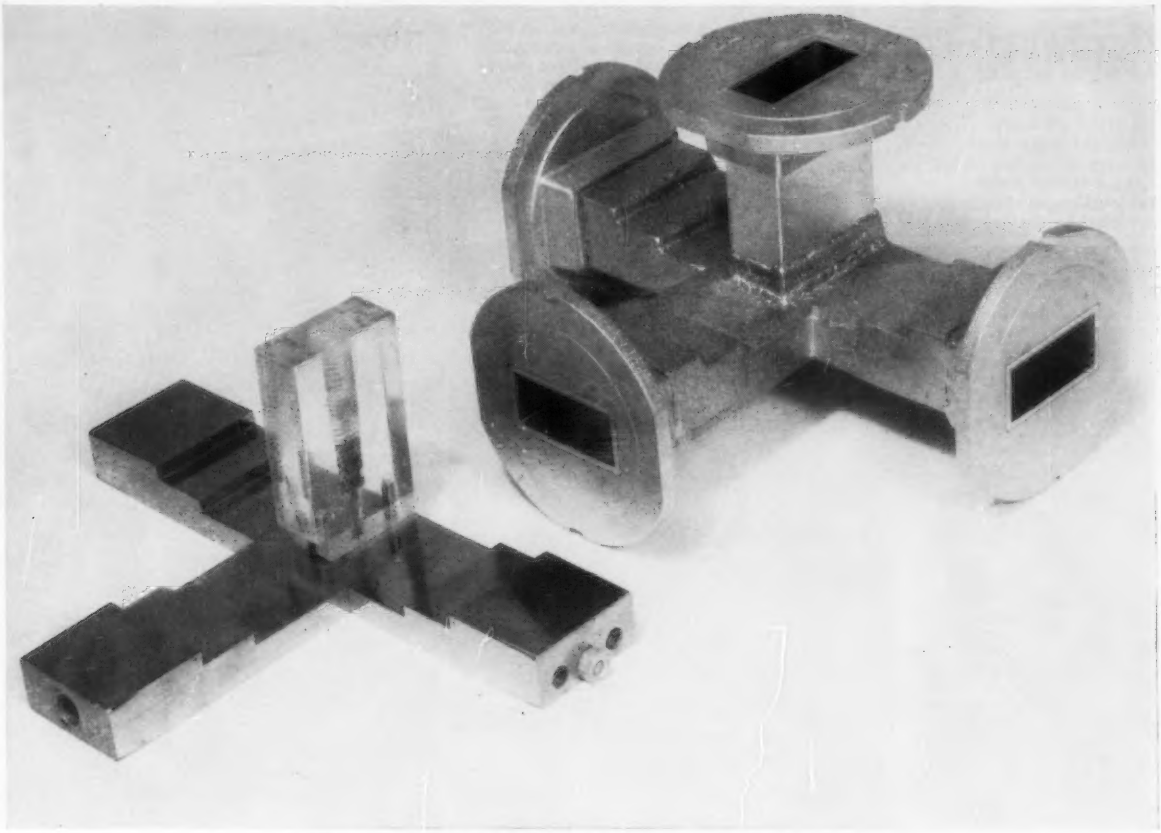
Acid-formed copper	10 to 15 tn/sq in.		40 to	55 Brinell	
Cyanide-formed copper produced by periodic reversal method	45 "	47 "	200 "	250 "	
Cast copper	10 "	11 "	40 "	45 "	
Annealed copper	14 "	16 "	45 "	55 "	
Cold-rolled copper	20 "	26 "	80 "	100 "	

Alkaline baths consist of copper cyanide and caustic soda, or potassium cyanide and caustic potash. Acid baths contain copper sulphate and sulphuric acid in the following amounts per imperial gallon, 32 oz copper sulphate and 9 oz sulphuric acid. This latter bath has been standardized at the Royal Radar Establishment, as it gives the easier and less exacting process. Plating shop staff can quickly analyze it without the assistance of a chemist and it is worked at the moderate temperature of 75° F.

For other parts, the cyanide bath may be more attractive, or even, dictated by the need for high strength metal. The rate of deposit can be increased and the ability to 'throw' is greater than with the acid solution. This means that the metal will form more readily on difficult surfaces and in small cavities. Objections include the high working temperature of 180°F, which precludes the use of most plastic mandrels; and their toxic nature. The need to agitate and filter continuously is a drawback and analysis is more difficult.

A good example showing detachable plates on the mandrel which are employed to form the recess seen on the finished part. Mandrel is entirely expendable because of the impossibility of withdrawing from the finished part.





"T"-joint shows ordinary flanges which have been grown in position. Again, mandrel is of composite construction to allow withdrawal.

Design Points and Technique

Fixing flanges and threaded bosses to the tubes is easily accomplished by 'growing on' no matter what metal is used. For this technique the parts are clamped to the mandrel with all surfaces except the joint surface masked off. When the copper has been deposited there is a solid high-strength connection between the parts. Tests prove the joints at least equal in strength to the metal deposited, with failure occurring away from the joint at around 11 ton/sq in. tensile and up to 2 tons/sq. in shear.

Certain design points have to be observed in electro-forming. For instance, where two faces join each other at a sharp corner the deposit on one face will not blend with that on the other, thus a plane of weakness is automatically formed. Basically the corner radius must be at least equal to the thickness of deposit. This point has to be watched when growing on an end flange; the accompanying illustration shows where a weak plane will form and how the job can be done correctly in two stages.

Orientation of the mandrel relative to the electrode plays an important part in determining local wall thickness. Some shapes are such that metal will build up quicker on one surface than others. There is always a tendency to thicken up on sharp corners and although this does not matter on waveguide tubes it may add weight and have to be machined away afterwards. By placing glass or plastic rods in the vicinity of corners, a more even distribution can be obtained, however, their positioning is largely trial and error.

New Metallic States

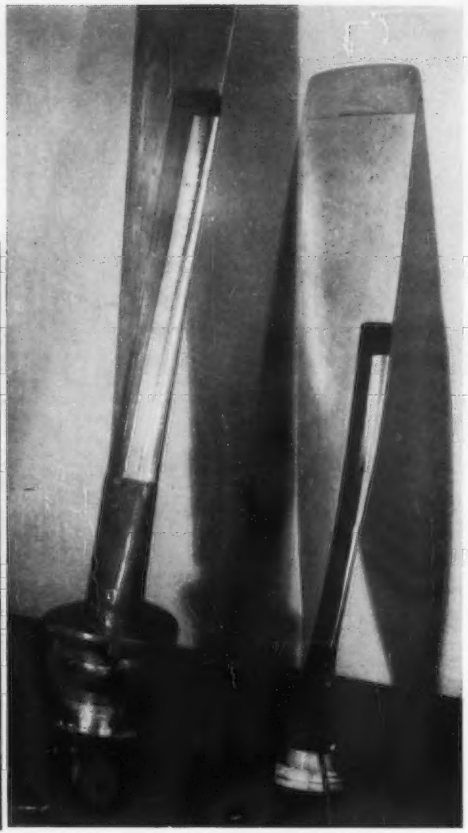
Metachemical Processes Ltd., an Anglo-Canadian concern, concluded that the grain size of the grown metal is a function of the surface it is thrown onto. Since the mechanical properties of any metal are a function of the grain size (the smaller the better), experiments were started to find what surface would give the smallest grain. Eventually a graphite filled thermoplastic surface was adopted.

Using this surface, and a standard Watt's bath, Metachemical has grown a form of nickel

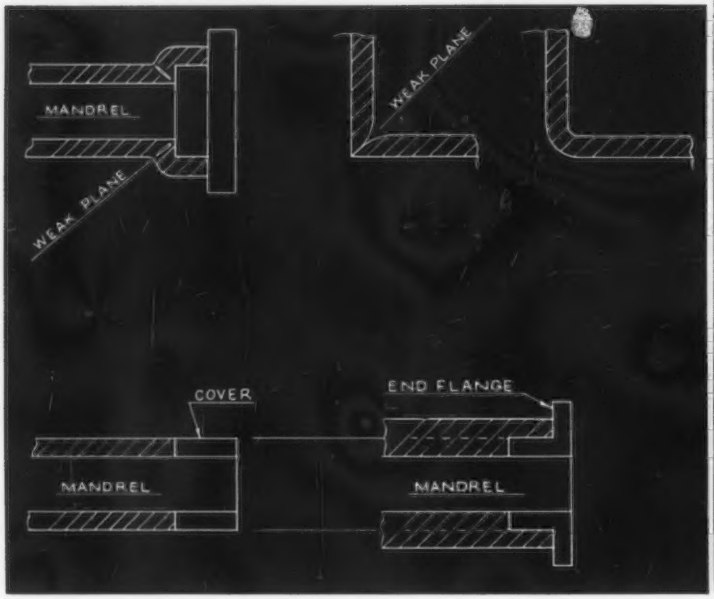
"growing" components...

continued

Leading edge shields made of micrograin nickel, protect deicer elements on British airliner.



FLANGE DESIGN
Inherent weak face results where two plates join if radius is not at least equal thickness of plating deposit.



that has a grain structure so fine that considerable difficulty has been experienced in determining its size. This feature has given rise to the descriptive title "micro-grain nickel." At the base surface the grain size is of the order of ¼ micron, increasing only slightly in the adjacent layers. Hardness is just over 600 Brinell, which can be compared with a figure of 200 for cold drawn nickel. Despite this hardness the metal is not brittle and sheet 0.012 in. thick can be bent 360 deg round a ¼ in. diameter bar without a sign of cracking. Ultimate tensile strength is 62 tons/sq in. and again this should be compared with 40 tons/sq in. for the cold drawn material.

Such properties make this metal very valuable in the form of thin protective sheaths for the leading edges of airscrew blades because of its high resistance to errosion. These along with turbine intake sheaths are now in production for military and civil aircraft in Britain. Severe trials representing speeds up to 500 mph have shown them to be superior to other types of de-icer and errosion.

To make the components, a female mandrel of the required shape is coated with the thermoplastic to a depth of several thousandths of an inch. A flash coating of copper is then deposited before immersion in a Watt's bath. It is claimed that the lack of organic agents in this solution accounts for the ductile nature of the metal. Such agents would clog the grain boundaries and thereby give weak planes along which early failure takes place. By correct orientation of the mandrel it is possible to get leading edge sheaths correctly graded in thickness tapering from about 0.025 in. at the nose to 0.007 in. at the edges.

A surprising feature is that the metal is under a self-induced compressive stress. It is this fact that makes it different; platings are generally under tensile stress. As a production feature the compressive stress is very useful, as sheaths naturally try to hug the contour as closely as possible.

Further experiments are being made with this form of plating, some of the highlights are: copper with a Brinell hardness of about 350, and a lead hard enough to be used for bearings. However, it is not yet known whether the lead will recrystallize and revert to normal grain after a prolonged period. Thus far the parts manufactured have all been of complex shape difficult to produce by any method other than electroforming.

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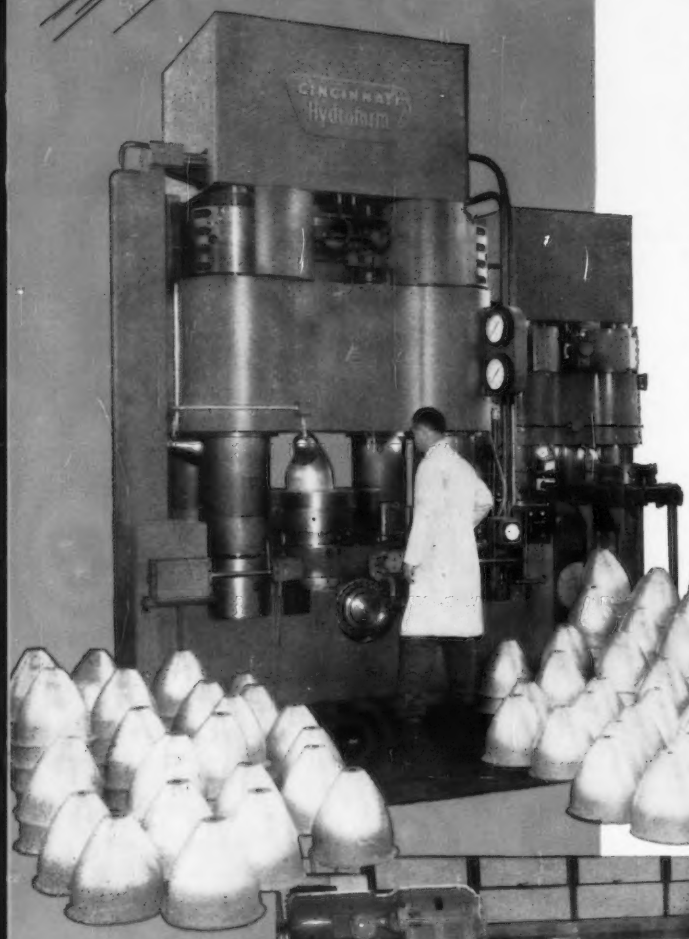

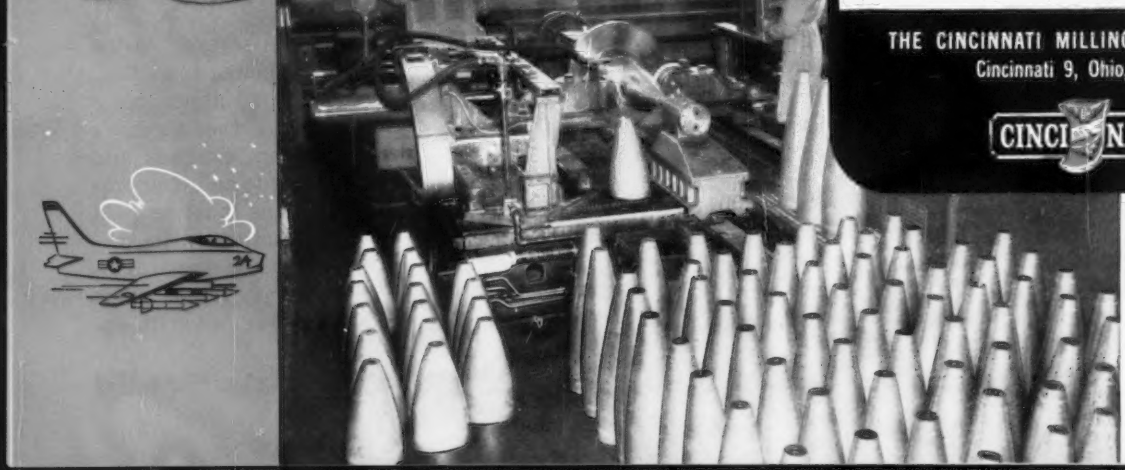

Cincinnati Hydroform · Hydrospin

make the nose sections flow for TAPCO GROUP of *Thompson Ramo Wooldridge Inc.*

Tapco Group, contractor to supply nose sections for the highly accurate, air-to-surface "Bullpup" missile, employs Hydroforming and Hydrospinning to form these parts at high production rates.

Photo at left shows preforms being produced with minimum thinout, on a Cincinnati 32″ Hydroform®, at rate of 90 per hour. Preform is of 6061 Aluminum, 14″ major diameter x 13″ deep x ⅛″ wall thickness. Preforming is a sub-contract operation by Jones Metal Products Co., West Lafayette, Ohio.

The preform is heat-treated, then "*chipless machined*" on the two-roller Cincinnati Hydrospin® in two operations (bottom photo). First spinning roll-flows the preform to 20″ length x 12″ major diameter x 0.080″ wall thickness, in 3½ minutes. Final spinning increases part length to 40″ and reduces wall thickness to 0.040″. Floor-to-floor time, 4¼ minutes.

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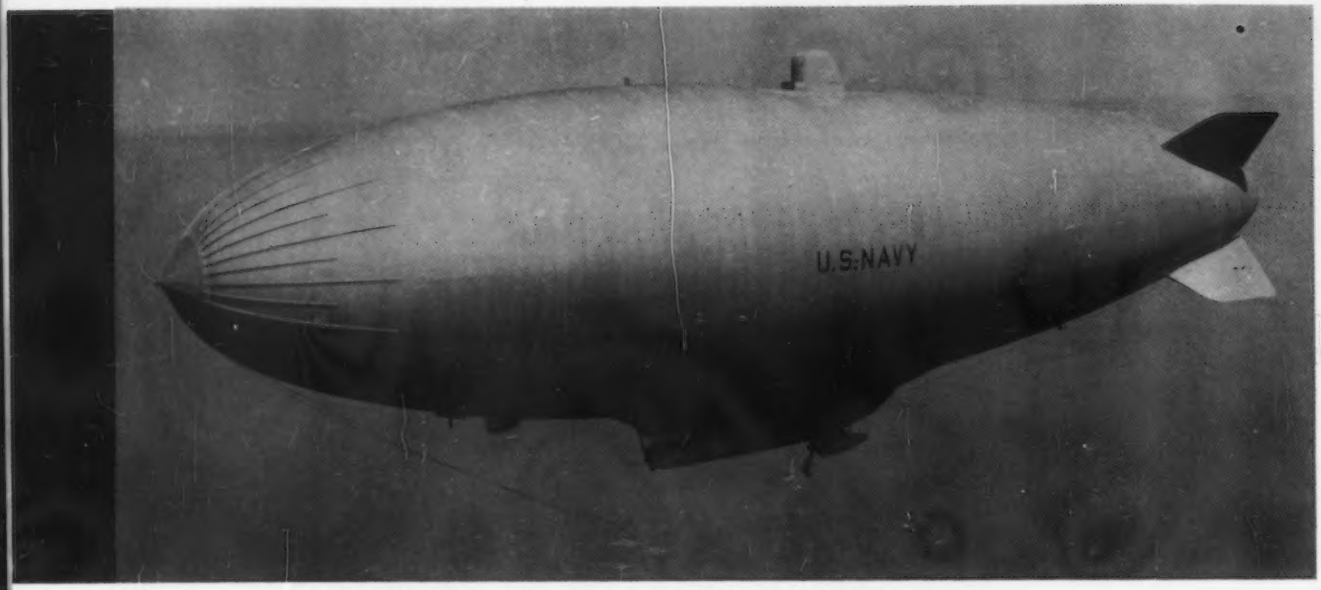


Nonrigid airships, described as "45,000 lb on a bubble," are an important part of Navy's anti-submarine program. Fiberglass nose plate and reinforcing battens are visible in photo.

non-rigid airships

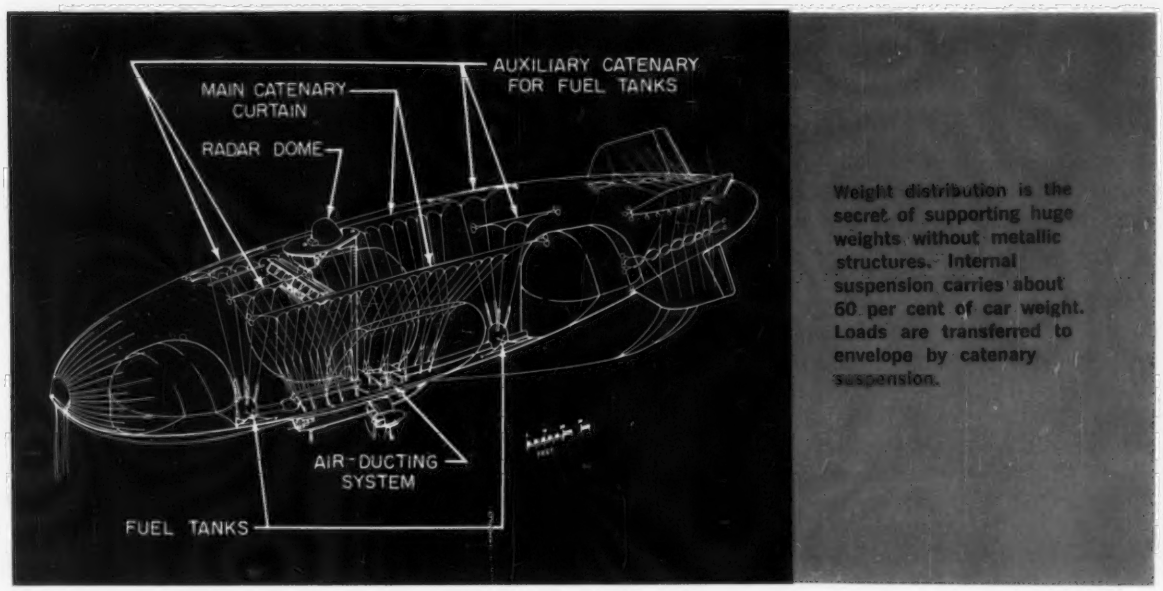
design and construction details reveal weight distribution is essential for supporting huge loads on fabric shell

by John Kevern

Nonrigid airship construction at Goodyear Aircraft Corp. amounts to "hanging 45,000 pounds on a bubble." A system of weight distribution which permits spreading enormous loads over the "blimp's" large area is the secret.

Modern blimps, or nonrigids, have no metal reinforcements inside the airship envelope, and without lifting gas they would be a shapeless mass of fabric. Due to the load distribution techniques, and the quality of the fabric used in the envelope; the car, huge control surfaces, antenna, and other gear can be attached as securely to the fabric as if they were welded or bolted to metal.

It requires only about 1-1/20 atmospheric pressure internally to maintain the airship's shape. However, since the helium expands and contracts with variations in altitude and temperature, internal pressure and volume must be held constant to maintain proper inflation of the envelope. This is done with ballonets or diaphragm-like air chambers into which air is forced when the helium contracts, and released when it ex-



Weight distribution is the secret of supporting huge weights without metallic structures. Internal suspension carries about 60 per cent of car weight. Loads are transferred to envelope by catenary suspension.

pands. The required air is supplied by ram-air intakes behind the propellers. A blower unit furnishes air when the engines are not operating.

Envelope

The fabric is of two-ply, rubber-coated, cotton or dacron. Weight-per-gage, tear-resistance, and dimensional stability is secured by cross-plying the two layers. The adhesive-rubber sealant coating is between the two plies. A proof coat is applied to the outside surface, and on top of that, a coating of aluminum paint for protection against weathering and heat reflection.

In manufacturing the fabric, quality control is based on weight per sq yd, rather than on gage or thickness. Each of the two plies is approximately 0.0185-in. when spread. The finished fabric is about 0.08-in. thick; total fabric weight is about 22,000 lb.

The envelope is divided in a number of gores running the length of the ship, and panels running around its width. Circular panels are used on the nose and aft end. In airship construction, sewing is analogous to the riveting used in aircraft fabrication. The panels are overlapped and sewed together. The stitching is then cemented, and rubber-impregnated fabric tape is applied over the seams to insure helium tightness.

The three ballonets are made similarly, but the material used is much lighter, and sewing is omitted since the ballonets are not under much stress.

Two rip panels are provided, for an aft, on the top centerline of the envelope, for rapid deflation in emergency situation.

Weight Distribution

All loading is transferred to the envelope through catenary suspension systems. The internal suspension carries about 60 per cent of the weight of the car. This load is carried on steel cables which are sewn into the catenary curtains. These two parallel catenary curtains are sewn into the longitudinal seams near the top of the envelope, and off the center line. They extend over about 70 per cent of the length of the envelope. The outside catenary system, which supports about 40 per cent of the weight, has its two parallel catenary curtains sewn into longitudinal seams near the bottom of the envelope, in the area of the top of the car. Their pull is almost horizontal. Additional weight, such as fuel tanks, can be suspended from the envelope, provided suitable catenary suspension is attached.

Air Pressure Control

Air from the propeller slipstream is scooped in through clamshell doors on the leading edges of the engine outriggers. It passes into a plenum chamber and then into a system of ductwork located in the ceiling of the control car. Through a system of check valves and dampers, air can be sent as needed into any or all of the three ballonets. In emergencies, air can also be sent into the helium area to maintain the envelope's shape until a landing can be effected.

A vital part of pressure control are the air valves, of which 21 are required on the largest nonrigids. These have a 28 in. diam; 7 are used for the helium gas and 14 for air. Although these are large valves, they must operate from fully

open to fully closed on a pressure of only ½-in. water. For the same reason, sealing of the valves on their seats is also critical. Goodyear manufactures the valve dome by an aluminum spinning process.

Assembly

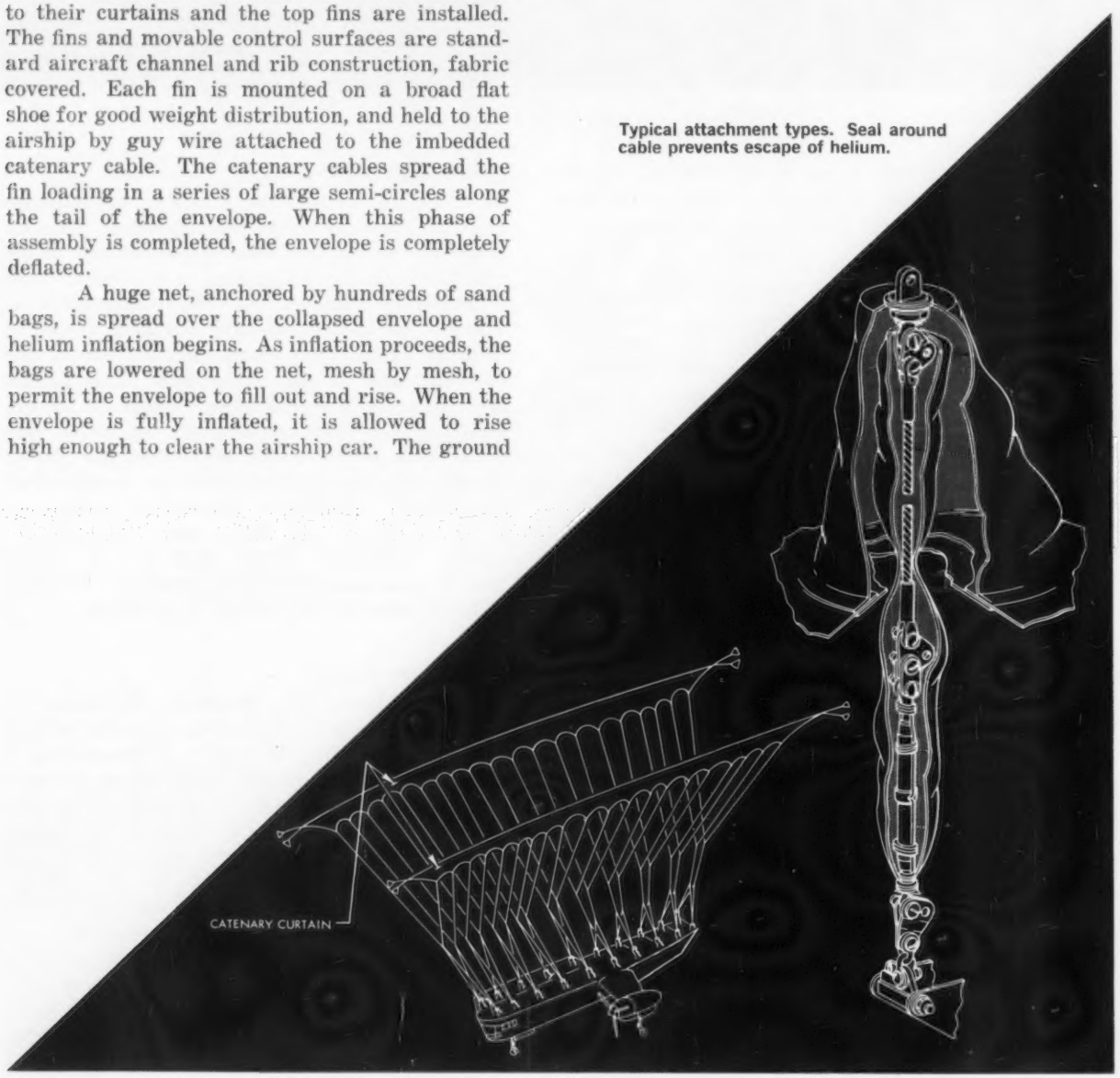
The envelope is spread out on a large, cleanly-brushed ground cloth on the hangar floor. It is first inflated with air for a re-inspection check. In the gloom of the interior of the bag, small holes show up as bright spots of light.

The interior satenary cables are attached to their curtains and the top fins are installed. The fins and movable control surfaces are standard aircraft channel and rib construction, fabric covered. Each fin is mounted on a broad flat shoe for good weight distribution, and held to the airship by guy wire attached to the imbedded catenary cable. The catenary cables spread the fin loading in a series of large semi-circles along the tail of the envelope. When this phase of assembly is completed, the envelope is completely deflated.

A huge net, anchored by hundreds of sand bags, is spread over the collapsed envelope and helium inflation begins. As inflation proceeds, the bags are lowered on the net, mesh by mesh, to permit the envelope to fill out and rise. When the envelope is fully inflated, it is allowed to rise high enough to clear the airship car. The ground cloth is removed and the airship car rolled into position. The internal catenary cables are attached, then the external system. Fairing is then placed over the external catenary cables to give smooth flying contour to the ship. With the car attached, the net can be removed.

The remaining fins and controls are attached, and the control cables installed. Power plants and propellers are installed and tested and the complex air and helium system is installed.

The nose is next stiffened so it will not "cup in" during high speed flight and to provide a strong point for the bow mooring attachment.



Typical attachment types. Seal around cable prevents escape of helium.

Tapering fiberglas battens are laced to the bag, leading up to the nose cone, which is also of fiberglas. The metal mooring eye is mounted on the end of the sliding metal mooring spindle, which has a shock-absorbing arrangement.

Installing Radome

Installing the high radar antenna inside the inflated envelope presents an unusual problem. It has to be installed in one piece; this means it has to go in after the envelope is fully inflated with helium. The airlock principle is used, and the entire assembly is inserted from above. The airlock is fastened over the access port, which is covered by a diaphragm to seal in the helium. This diaphragm is then removed and the antenna lowered into position. After antenna support structure is sealed, the diaphragm and the sidewalls of the airlock are removed. The men work through hand-holes much like the old photographic changing bags. In this way very little helium is lost. Everything must be done from outside, since no one enters the envelope itself after helium inflation.

The radar antenna is supported by a large metal platform or "snowshoe," which spreads the weight over the top of the envelope fabric. This snowshoe also supports the topside height-finder radome and radar equipment. This top section is sealed off from the helium in the envelope, as is the access shaft from the car below. This shaft is of fabric, with metal ring reinforcements to hold its shape and also serve as the ladder to reach the platform.

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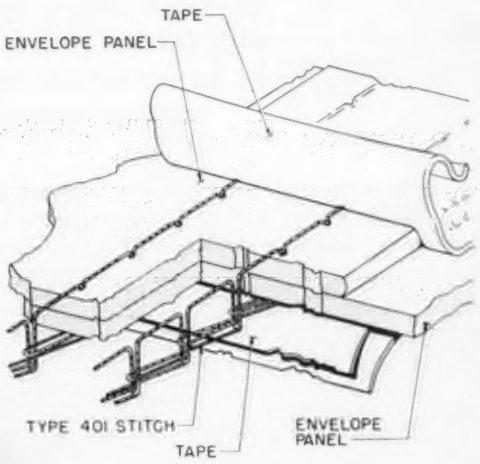
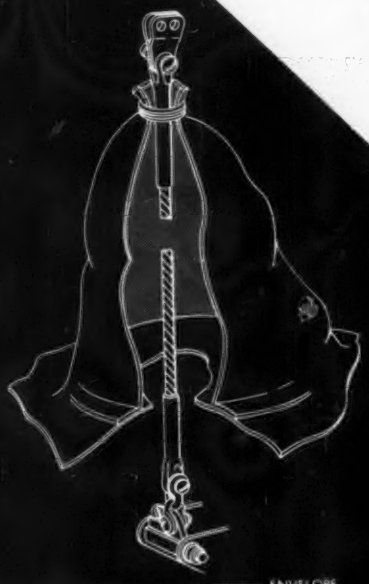
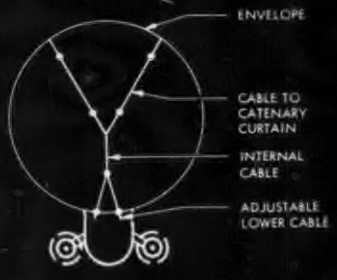
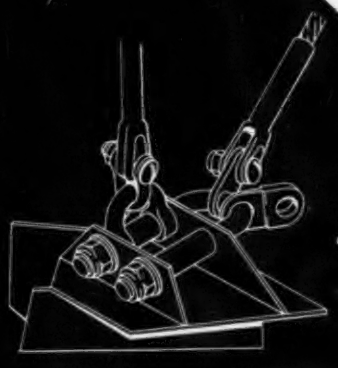
Stitching is substitute for riveting. Fabric is two-ply, rubber-coated dacron or cotton. Adhesive rubber sealant is used between plies. Tape is applied over stitching.









engineering and flight report:

Alouette II

by Norman Lloyd

Republic offers light turbine-helicopter with service proven components; design reduced to essentials of performing mission without seriously cutting versatility

The helicopter industry has suffered long and hard from the lack of planned parenthood. While many manufacturers are busy breeding or bearing "brain children", Republic Aviation is attending to the development of the Alouette II, a promising youngster that was born in France some time ago.

As a result, the Alouette enjoys the distinction of being the first turbine helicopter for U. S. customers that is fully certified and thoroughly proven. It has behind it a great deal of practical experience including service with operators in the U. S. and 18 foreign countries.

Rather than risk lead time and a great deal of money in bringing their own machine to market, Republic made arrangements with Sud Aviation to sell and service the Alouette in North and South America. The licensing agreement provides for the initial manufacture of all components in France. Eventually, domestically produced components will be phased into the program.

It is universally agreed that if the economics of operation are to be kept to acceptable levels, the helicopter must be relatively free of mechanical complexity. It should also exhibit a good ratio of useful load to gross weight for a variety of environments. Republic is convinced that, for its class, the Alouette satisfies these requirements. In making use of proven components, it also eliminates a sizeable proportion of "unknowns" for the user to nail down.

Certification was completed in January 1958, with a minimum number of modifications requested by CAA. These included the installation of a firewall, relocation of the fuel filler neck, domestic instrumentation and some additional performance curves on the powerplant.

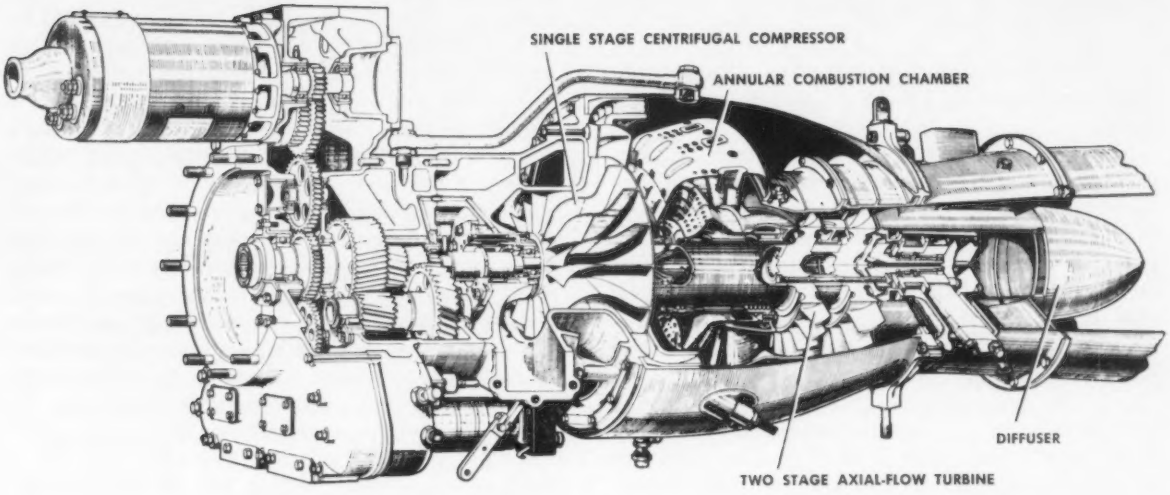
General

Of "classical" configuration, the Alouette employs a single three-blade fully-articulated main rotor and conventional tail rotor. The fuselage is a welded-tube truss-type structure. Dural skids are provided for landing. Power is supplied by a Turbomeca Artouste II-B1 shaft turbine with a max rating of 400 hp and a max continuous rating of 360 hp. There are seating accommodations for five, including the pilot.

Design Features

The Artouste engine is comprised of (1) a single-stage centrifugal compressor, (2) an annular, straight-flow combustion chamber into which fuel is injected by centrifugal effect, (3) a two-stage axial flow turbine, and (4) a diffuser

Turbomeca—Artouste 11-B1 connected-shaft turbine data.



POWER UNIT DATA

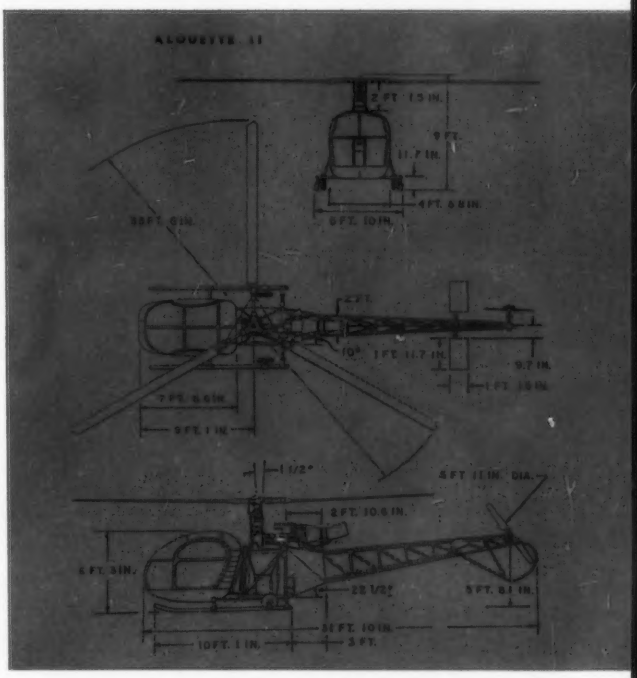
Number of turbine	One
Type	TURBOMECA Artouste 11-B-1
Direction of rotation	Clockwise when viewed from front of aircraft
Maximum r.p.m.	35,000
Normal r.p.m.	33,000
Dry weight engine, including accessories	353 lbs.
Maximum permissible powers	400 hp.
Maximum continuous power	360 hp.
Residual thrust	approximately 65 lbs.
Fuel	Kerosene to specifications F-33 Esso—Avtur 40 Shell—#640 Military: JP-1, JP-4, MIL F-5616
Lubricating oil (turbine & gearboxes)	Esso—#57 Shell—Aero Shell #9 Military: ANO6A or any commercial equivalent
Turbine speed	Constant r.p.m. maintained under all load conditions by a governor unit
Starting	Starter-generator, 100 amps —28 volts
Fuel consumption in sea level cruising conditions	330 lbs. per hour

which reduces the velocity of exhaust gases to less than 330 ft/sec.

For this installation, an engine speed of 35,000 rpm delivers 400 hp. A built-in reduction gear with a ratio of 5.8 to 1 provides an output shaft-speed of 5680 rpm. The tail pipe is fitted with a venturi-type ejector which speeds the flow of outside air for cooling the main gearbox lubricating oil.

The engine is mounted on the aircraft structure at three points, two at the front and one at the rear. These are designed to allow the engine axis to be readily and accurately aligned with the main driveshaft axis.

Since both rotor and engine operate at constant governed speeds, power variation is accomplished by automatically adjusting the fuel flow. Engine operation depends upon two controls located at the base of the pilot's console. The fuel-flow control, when fully opened, allows the engine to reach 28,000 rpm following start-up. Above this rpm, the governor-control determines fuel-flow and is used to select speeds to a max of 35,000 rpm. When the governor reaches its upper



Alouette II . . . continued

limit, fuel-flow cannot be increased. This condition is indicated by a red light on the instrument panel.

The governor is of the centrifugal constant-speed type. Its function is to maintain constant speed at all times, regardless of power demands required by blade-pitch changes.

A wet-type centrifugal clutch is provided on the main drive-shaft. The clutch operating oil also lubricates the main drive-shaft and freewheel assembly and the driving sprocket on the main gearbox input bevel.

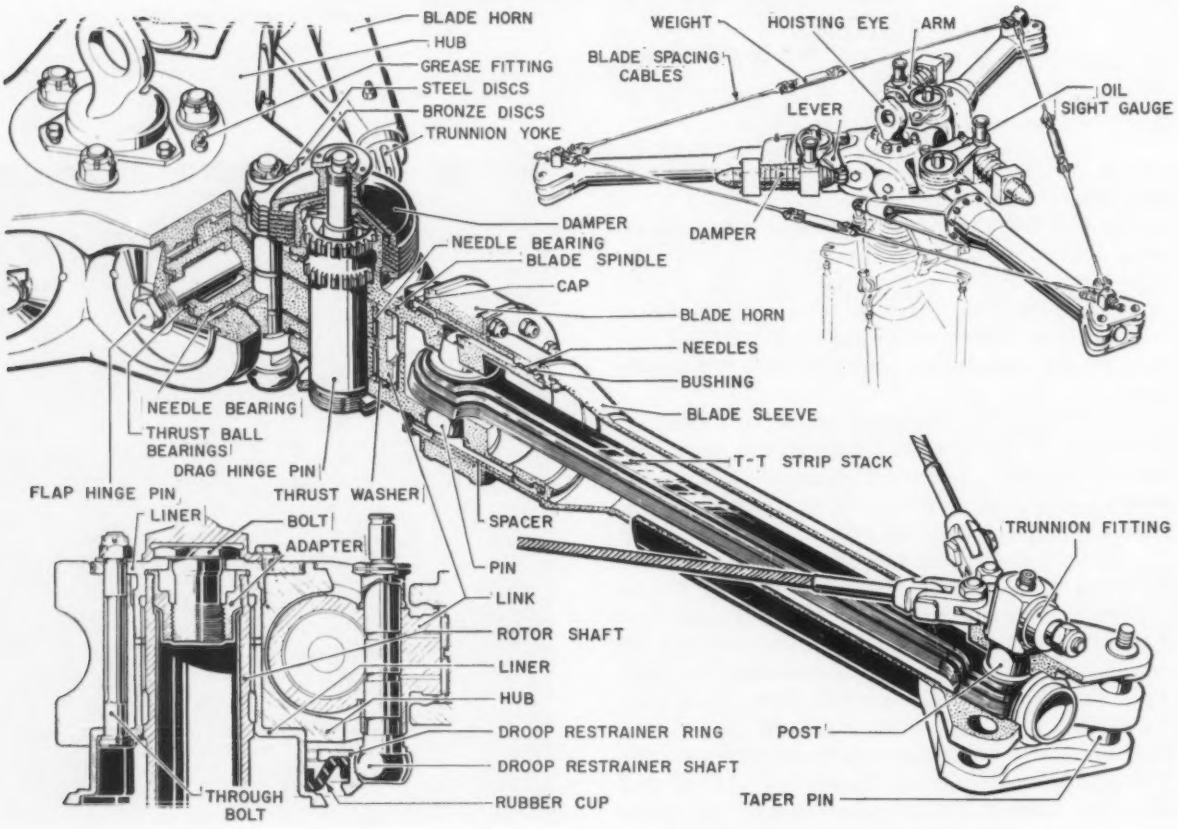
The main gearbox consists basically of input spiral-bevel gearing and two planetary reduction stages. Gear ratio is 16.32 to 1 between the main-rotor drive-shaft and the tail-rotor drive-shaft. All gearboxes are designed to accommodate a max rating of 600 hp.

The tail-rotor drive-shaft employs self-centering bearing hangers that eliminate the usual alignment problems. They are unevenly spaced along the shaft to reduce coupled vibration frequencies. The tail-rotor gearbox provides a 1.24 to 1 reduction for the tail rotor, and incorporates an axially-mounted pitch change mechanism.

The fully articulated main rotor-head is simple and uncluttered. Blade retention is through a stack of stainless steel tension-torsion strips housed in the blade sleeve. They carry centrifugal loads and eliminate the requirement for heavy-duty thrust-bearings. Dampers are fitted to the drag hinges to prevent excessive relative movement during the starting-stopping cycle. To avoid excessive blade droop at low rotational speeds, the hub is fitted with inter-blade droop stops which limit minimum coning but not cyclic motions. A blade-spacing equalizer system, consisting of cables interconnected to the blade sleeves, automatically corrects disturbances effecting inter-blade spacing. This system has the physical effect of offset hinges or blade-centering springs.

The main rotor blades are of parallel planform and have a uniform section from root to tip with a built-in twist.

Cutaway illustrates articulated rotor-head configuration, and blade-spacing cable arrangement.



Principal dimensions are:

blade area (theoretical)	43.5 sq ft
rotor disc area	880 sq ft
solidity	5%
diameter	33 ft 6 in.
chord	10.4 in.
airfoil	NACA 0012
twist	6 deg

The blades have an extruded aluminum alloy leading edge, to which is bolted a steel forged cuff. A light alloy skin is bonded to the spar and ribs. Aft of the spar, the blades are packed with Moltoprene foam. The trailing edge capping strip is rivetted to the skin, and trim tabs rivetted to the capping strip.

The cockpit structure consists of a metal frame covered by formed Plexiglass panels. Each of these sections can be individually replaced. The cabin is 52 in. wide and 82 in. long and is easily reached through doors about 4 ft square.

Conversion from passenger seating arrangement to cargo is a simple matter. Attached to the aircraft by eight quick disconnects, the rear passenger seat can be removed in less than a minute. The co-pilot's cyclic stick is removed by loosening a hand-tightened knurled nut, and freeing a snap-fastened boot. A leaf-spring snap and pin installation facilitates the removal of the co-pilot's collective pitch stick. Rudder pedals can be removed through one access plate on the cockpit floor.

Access to flight and engine controls is gained by removing one panel on the "belly" of the cabin structure. Repair and inspection of radio and instruments is made through hinged panels.

Two vertical hydraulic shock-struts, designed to dampen resonance characteristics at lo[w] rotor speeds, are hinged from the corner of th[e] rear-frame structure to the rear cross-tube of the landing gear.

Maintenance

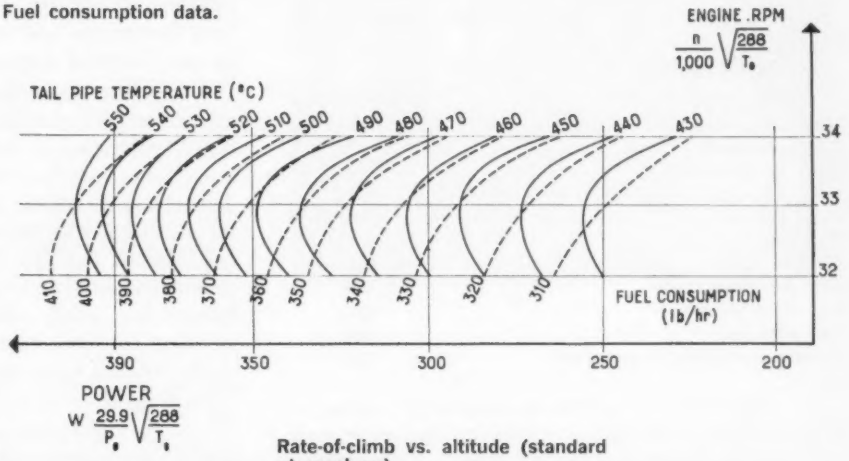
Helicopter maintenance costs, which are influenced by design simplicity, component life and accessibility, have "bugged" military and commercial operators for years. Republic's battle

Fuel consumption data.

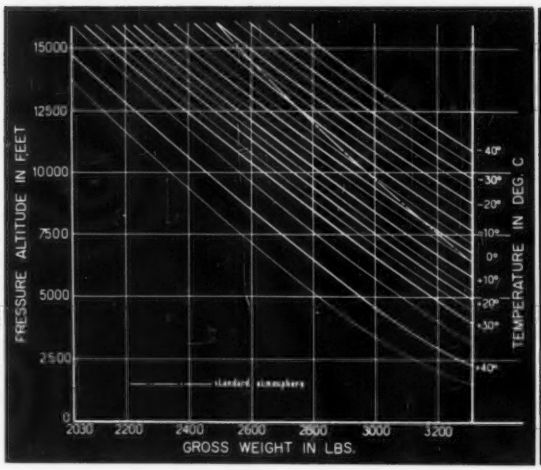
W = horsepower
n = engine r.p.m.
P_o = atmospheric pressure (in. Hg)
T_o = absolute outside temp.
C_h = Fuel consumption per hour
t_4 = tail pipe temp. (°C)

——— $(t_4 + 273)\frac{288}{T_o} - 273$

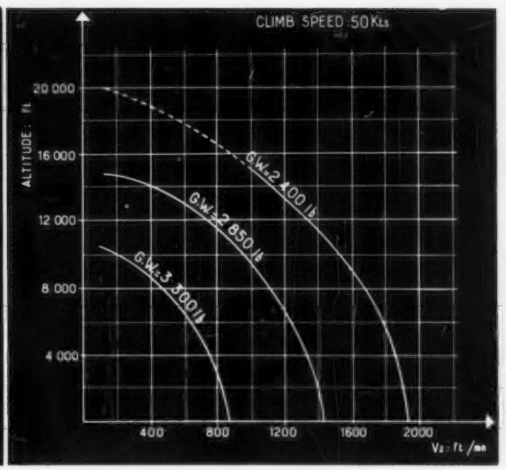
----- $C_h \frac{29.9}{P_o}\sqrt{\frac{288}{T_o}}$



Zero-wind maximum take-off weight (hovering - in ground effect).



Rate-of-climb vs. altitude (standard atmosphere).



Alouette II . . . continued

for recognition and acceptance is backed by favorable cost figures. Based upon operators' reports, the Alouette has compiled a record of less than one hour of maintenance for each hour of flight. Maintenance features:

- All oil-bearing assemblies contain oil-level sight-gages.
- All rotor-hinge bearings can be lubricated through one grease fitting.
- External access to all major assemblies is provided.
- Low silhouette permits rapid inspection and accessibility.
- Only one grade of oil, one grade of grease, and one type of hydraulic fluid are required throughout the aircraft.
- Engine change can be made in less than 30 min, transmission is less than one hr.
- A portable maintenance hoist can be attached to the airframe for dismantling the engine, rotor head, and transmission.

COMPONENT OVERHAUL TIME

Item	Overhaul Time
Main rotor blades	1200
Tail rotor blades	2500
Rotor head assembly	600
Mass assembly (including swash plates)	600
Main gearbox	600
Coupling shaft	600
Oblique shaft	600
Tail rotor drive shaft	600
Tail rotor gearbox	600
Tail rotor hub	600
Turbine (including accessories)	310

Optional equipment, such as certified floats, litters, spray equipment, wheel landing gear and all-weather instrumentation can be installed without major modification to the basic configuration.

Performance

The Alouette has made take-offs at 13,000 ft with high useful loads. Such capabilities enabled it to set a new world altitude record in 1958 for all-category helicopters of 36,501 ft.

With 1900 lb empty weight and 153 U. S. gallons of fuel, main performance figures for a max gross of 3300 lb are:

Max sea level speed	95 kts
Max sea level cruise	92 kts
Hovering ceiling in ground effect	8200 ft
Hovering ceiling out of ground effect	5250 ft
Sea level cruising range (with 20 min. reserve)	273 nautical mi
Economical cruise range	325 nautical mi
Normal cruising endurance	3¼ hr

The Alouette, through a combination of flapping-hinge offset and horizontal stabilizer trim (adjustable rigging angle of —5 deg to the horizontal datum line), has a CG travel of 13 in.; this is commendable for a single rotor configuration. There are no special internal loading requirements within the gross weight limits of the aircraft.

Flight Evaluation

The Alouette represents a heartening design philosophy of boiling a machine down to the barest essentials needed to perform a mission.

Of particular interest to pilots is the fact that the requirement for throttle-pitch coordination and constant monitoring of rotor speed has been eliminated. Due to the efficiency of the engine governing system, there is no need to anticipate power demands. Power is plentiful, and response to changes in collective pitch is rapid.

Good handling qualities are the result of a combination of various stability and control characteristics. Without them, the aircraft's performance and operational capabilities cannot be realized. They are important to the pilot because they determine the ease and precision with which he can perform a mission.

Attempts to partially determine the speed and maneuver stability of the Alouette were partially frustrated by winds of 20 to 25 kts. Abrupt stick deflections were made, however, to purposely disturb stability for various trim conditions. Since no difficulty was experienced in anticipating the behavior of the aircraft, handling qualities were considered satisfactory. Decay of pitching oscillations was good. For standard rate turns and varying forward speeds, a minimum number of stick motions were required to prevent deviations from the intended flight path.

A "do-it-yourself" yaw indicator, consisting of a nose probe with red yarn attached, served as a reminder that directional control for changes in power are reversed to that of domestic helicopters. Since the direction of rotation of the main rotor is clockwise, rudder position is the same as fixed wing aircraft.

High kinetic energy of the relatively heavy main rotor permitted autorotational descents to be made over a wide range of rotor speeds. Directional control was excellent.

On the basis of only one flight, the writer considers the aircraft to be safe and readily controllable for normal missions under VFR conditions. It is a helicopter with a low "apprehension level" requiring no specialized handling techniques or lengthy indoctrination.

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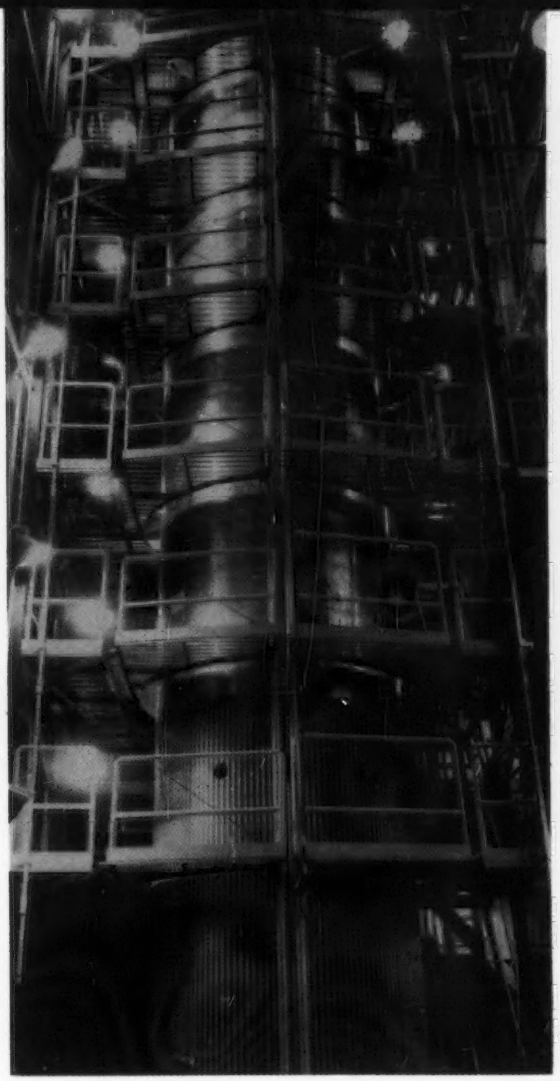
quality control in ballistic shells

reliability of Redstone and Jupiter partly due to thorough weld tests; X-ray essential, ultrasonics show promise

by Gen. J. A. Barclay, Commander, ABMA



Jupiter ballistic shell is tested in hydrostatic stand for leaks, after radiographic inspection of individual components.

During the early stages of Redstone development a number of serious deficiencies were partially attributed to structural and pressure vessel failures. No X-ray inspection was being made on the welds of the missile thrust section which contains these pressure vessels. An extensive study was begun, and all fuel and oxidizer tanks were subjected to radiographic tests. While this was time-consuming and painstaking—approximately 100 man-hr were required for each thrust unit—the results were most rewarding.

Nearly 200 plates, 17 in. by 4 in. were exposed to accomplish the inspection of each section making up these thrust units. On one unit as many as 60 per cent of the films showed defects in the weldments which would have significantly affected the reliability of missile performance. This particular thrust unit was subjected to a destructive hydrostatic test and failed at the working pressure; no safety factor was realized. By changing welding procedures and control methods, the percentage of defects was reduced to an average of less than 10 per cent in a few months. Today, this percentage is almost negligible. To cite a recent example, four JUPITER thrust units were X-rayed and found to contain not a single weld deficiency. With the attainment of these standards, and by the development of fabrication and control procedures both within ABMA laboratories and within the contractors' plants, the time required for these inspections has been much reduced, while the reliability and quality remain level.

Present Techniques

Present methods have reached a point where two X-ray technicians are able to expose, process, and analyze approximately 200 films in a single day. This represents about 3,000 linear in. of welds—approximately that required for a center section of one missile.

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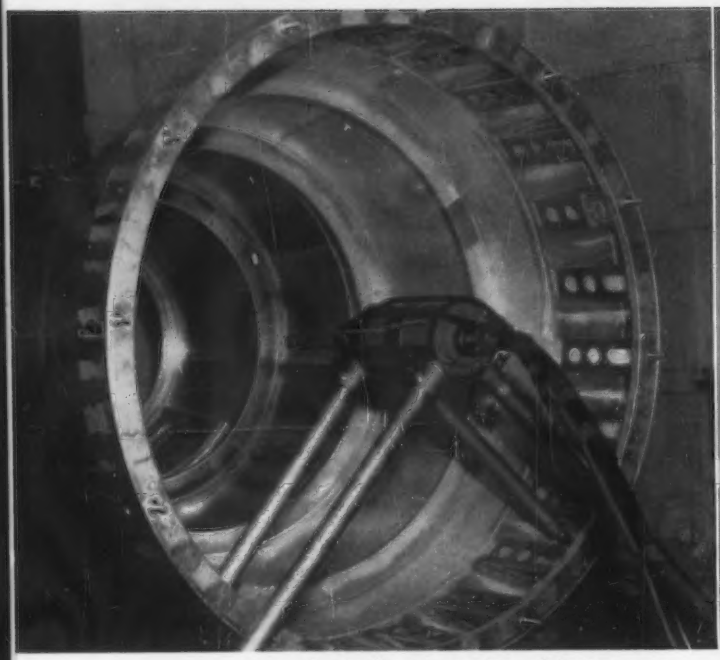
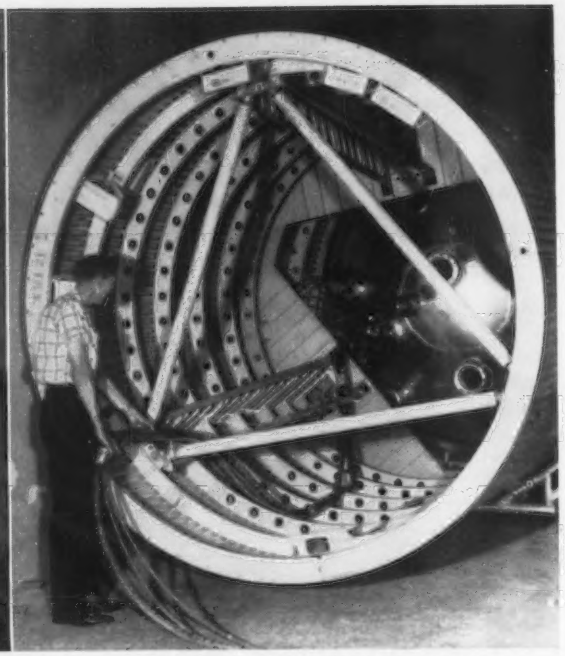


Jig for X-ray inspection of Jupiter cone is shown. 360 deg rod anode is used to assess quality of the substructure.



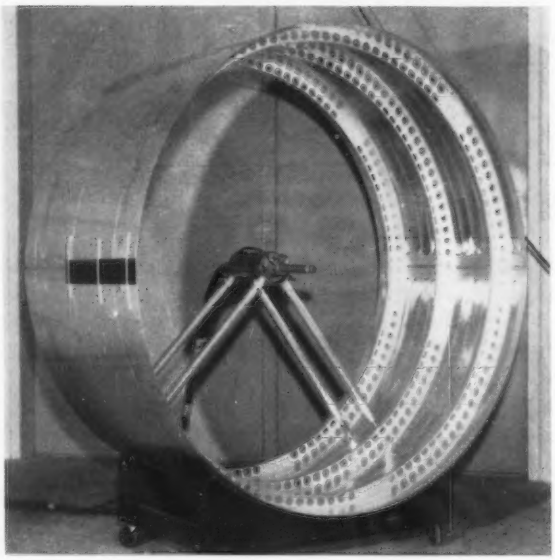
Nose cone section is also checked radiographically to locate any voids, cracks or fissures in the thermal insulation. Work is done in lead-lined room.

quality control . . . continued

Multiple exposures of complete circumferential welds are accomplished by the use of 360 deg rod anode X-ray tubes. The complete center section is composed of seven cylindrical segments. Each segment is fabricated from two formed aluminum alloy sheets containing two longitudinal welds. These welds are inspected radiographically, as illustrated, and necessary repairs made before any further fabrication is attempted.

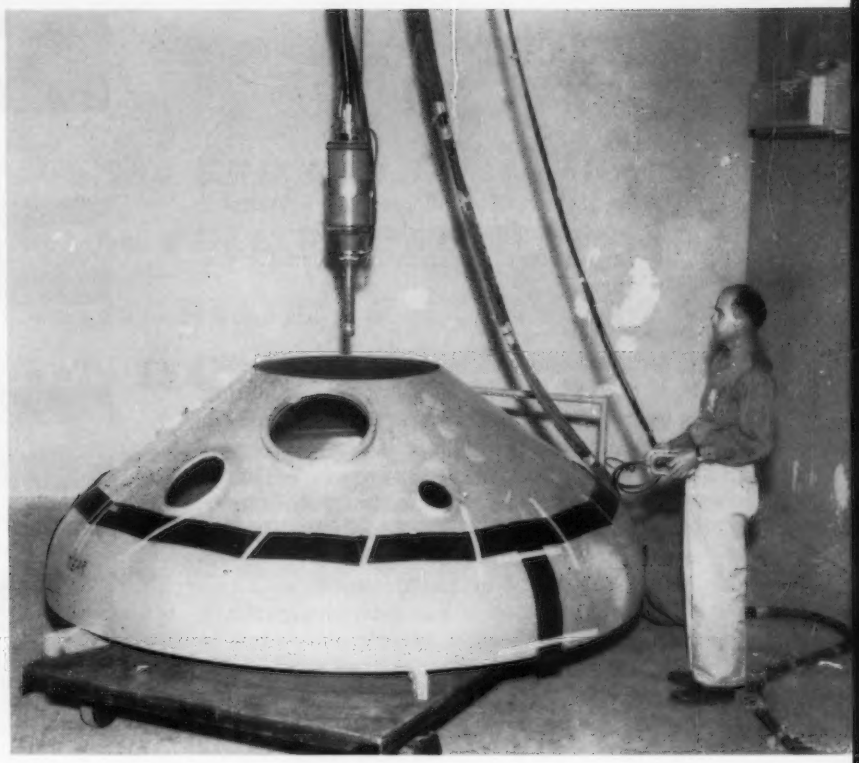
When the X-ray films have been processed, they are evaluated by the X-ray group leader and if it is determined that these deficiencies exceed previously established limits, the sections are returned to the assembly line for repairs. After determining that weldments are of the desired quality, the segments are joined together one at a time by a circumferential weld. In addition, reinforcement rings and bulkheads are added, completing the total ballistic shell. Facilities for accomplishing the X-ray work are located adjacent to the welding assembly line in a lead-lined room large enough to contain the entire missile thrust unit and tail assembly. The flexible film cassettes are placed around the complete circumferential weld and the 360 deg rod anode X-ray tube is placed in the center of the section by means of a special adjustable ring. Thus, multiple exposures are made which reduce significantly the time formerly required where only single exposures could be made.

360 deg rod anode X-ray jig is also used on each of seven cylinders that comprise center section of Jupiter. Sections are then joined by circumferential welds. These welds are also checked with multiple exposure X-ray.



Testing Other Units

Following complete radiographic inspection, the ballistic shell is sent to the hydrostatic test facility immediately adjacent to the X-ray facility. Here it is determined if leaks or structural weaknesses exist. In this manner ABMA ballistic shells are built up and thoroughly tested prior to completing the total missile.



Pressure bulkhead weldments are checked with portable device. Film (shown as dark ring) is attached to circumference of tank top.

Another important item subjected to radiographic testing is the nose cone for the Jupiter. That critical element of the warhead of the IRBM that must withstand the tremendous heat of friction as it re-enters the atmosphere on the terminal portion of its trajectory. X-ray inspection is utilized to assess the quality of the substructure and the thermal insulation of the nose cone for voids, cracks, and fissures.

To mention one further item, as ABMA gets into the new Pershing missile program, the X-ray of the solid propellant motor will be used to determine the homogeneity of the propellant. This is vital to any solid propellant missile to insure a uniform thrust throughout duration of the motor's burning.

Military Spec Not Adequate

To insure that the material provided to ABMA by the many subcontractors and vendors is of the quality desired, it has been necessary to establish detailed specifications and standards for these parts. A considerable amount of work has been done to correlate radiography with the inherent mechanical and physical properties of weldings and castings. Radiographic acceptance standards have been prepared for all types of weldments, castings, and other component parts. Although many existing military specifications are used, they are not always satisfactory for specific applications and must be supplemented by more applicable documents. Such documents have been prepared and refined and are available to all who supply material to ABMA.

One such document covers the soundness requirements for fusion welds in aluminum and magnesium. Included is a means for classifying weld defects. An example is illustrated. Class I denotes a defect-free weld, while Class V denotes a poor noncritical weld. The need for updating existing standards and specifications for use in missile work is one of the problem areas that has consumed much engineering effort.

The X-ray equipment utilized at ABMA, while it has had to be adapted for some special fabricating processes, utilizes wherever possible standard equipment. A 150 kv machine fulfills 90 per cent of the inspection requirements. This equipment has to be extremely flexible, have a fine focal point, and b portable for missile application.

Other applications of radiography which are used are:

- Fluoroscopic monitoring of liquid flow through pressure vessels to study liquid vortexing.
- Determination of charge placement in explosive bolts and squibs.

continued on next page

- Inspection of small pressure systems to locate foreign particles.
- Inspection of ceramic and cermet structures.

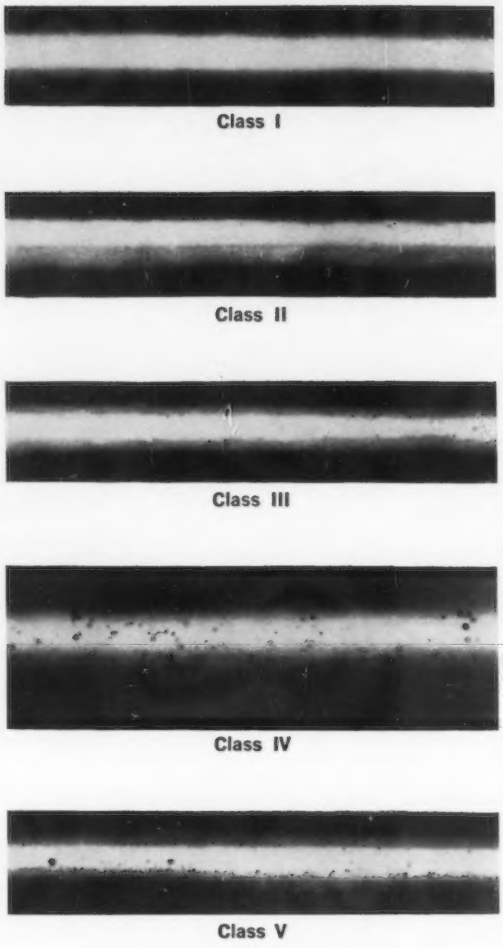
Ultrasonics Grow

One problem area in using X-ray inspection methods at ABMA is that it is time-consuming. While every effort has been exerted to reduce the inspection time required, there is a certain logical minimum which is ultimately reached. In an effort to reduce this fabrication time still further, a considerable amount of work has been done to develop ultrasonic methods of inspection. In recent years, the use of ultrasonic energy as a tool for nondestructive testing has shown a significant upward trend. Low-level ultrasonic energy can be utilized to inspect both metallic and nonmetallic materials without the hazard of harmful radiation to operating personnel. To date the ultrasonic technique has been used successfully to determine defective areas in all types of metals, including wrought sheets, extrusions, and to some degree, castings. Extensive development has been undertaken to apply ultrasonics to the inspection of fusion, spot, and seam welds, with considerable success having been achieved in the case of fusion welds.

In many cases the type of defects uncovered by the ultrasonic method indicates that this method is more sensitive than X-rays. However, although many quality-control applications which formerly utilized radiographic techniques are utilizing ultrasonics now, ABMA does not consider ultrasonics as a replacement for radiography. Rather, it is a supplemental tool for use in specific applications.

Other Nondestructive Tests

Several other nondestructive inspection tools are available to the quality-control engineer. The magnetic-particle inspection systems are most useful for determination of all surface and some sub-surface defects in ferro-magnetic materials. Also, the dye-penetrant inspection systems are useful in determination of surface defects in nonmagnetic metallic materials. Although both of the systems are limited, in general, to determination of surface defects, they are most useful in supplementing other tools. They are economical and require only short periods of time. One of their big limitations is the lack of a permanent record of the results.



New standards were developed at ABMA for fusion welds in aluminum and magnesium. Class I denotes defect-free weld, Class V denotes poor weld.

Reliability

In missile programs, where telescoping of time and schedules is now an accepted fact, the development of the quality-control program by the contractors must take place during the latter phase of any development program to insure its adequacy by the time production-line operations begin. While the reliability of any missile system is inherent in its basic design, it is the function of the Government's quality-assurance program and the contractors' quality-control program to maintain this reliability through production. By the feedback of information on defects found during the development and production phase, the design engineer may effect redesign which will further raise the reliability of the basic system. By these integrated and closely monitored reliability and quality-assurance programs, the Government assures itself of a better product.

✦

When the END RESULT must be FULL RELIABILITY

MAGNAFLUX TEST SYSTEMS

supply the MEANS

In today's missiles and aircraft, so much depends upon so little! As aircraft and missile men know, failure of just *one* of the many components linked together in complex systems, can put the whole system "out of business." *Every part* has become a critical part!

In this equipment chain, parts of *normally* high reliability can be intolerably *unreliable* as part of the whole interdependent system. When one failure in 1000 is too many — and may cost a million or more dollars — only reliability standards approaching the fantastic are good enough.

Similarly, only scientific inspection and testing systems can hope to maintain such standards.

Magnaflux Nondestructive Testing Systems provide the means. Proven practical and economical in just such uses, they enable you to assure the physical reliability of components — whether precious one-of-a-kind units or volume production items. These Test Systems are so precise in their findings that, in their recommended service, *not a crack, leak, or defect* that you need to find will go undetected. They cover the whole range of magnetic or nonmagnetic metals, ceramics or other materials you work with, design for, or fabricate. Also, eddy current Magnatest equipment controls metallurgy, heat treat, hardness, etc. — in further nondestructive tests.

These Magnaflux Test Systems are currently helping to assure near-infallability of materials for producers of components used in many missiles and aircraft. They are providing testing standards *to fit the need* . . . helping to keep both testing and production schedules *on schedule* . . . and saving a great deal of money for prime and subcontractors besides! Note, too, you don't need to buy test equipment. We have service testing facilities in 16 cities.

To find out what Magnaflux Test Systems can do for *you* write for a meeting and idea session with an experienced Magnaflux Engineer. You set the time and place. There's no obligation, of course — but plenty of help for the asking.

MX Test Systems—used for *more* test operations than *all* others—include:

MAGNAFLUX-MAGNAGLO
Magnetic particle testing for cracks and defects in magnetic metals.

ZYGLO
Fluorescent penetrant marks defects in nonmagnetic materials.

SONIZON
Ultrasonic testing for thickness or sub-surface defects.

STRESSCOAT
Brittle coating stress analysis.

MAGNATEST
Electronic testing for hardness, conductivity, cracks, etc.

Also others.
Tell us your needs.

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The Hallmark of *Quality* in nondestructive test systems

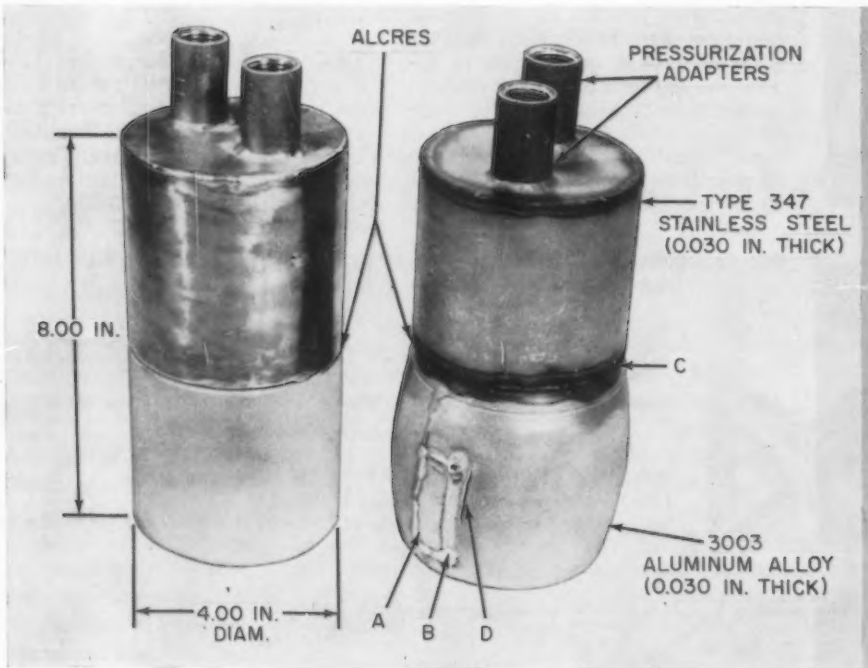
Circle 48 on Inquiry Card, page 81

brazing aluminum to stainless

process useful for composite structures in fabricating heat exchanger parts

by **Amiel Gelb,** director of laboratories
South Wind Div., Stewart-Warner Corp.

Certain applications in aircraft and missile design may require joints between stainless steel and aluminum. Such composite structures combine the light weight and high heat-transfer properties of aluminum with the higher strength and fatigue characteristics of steel. Heat-exchange devices, for instance, can incorporate dissimilar-metal structures with advantage. Familiar drawbacks, however, have barred the use of joints between dissimilar metals; chief difficulty being the wide



Two composite stainless-aluminum cylinders used for testing of brazed joints.

Typical heat exchanger unit with brazed area (inset) illustrates application of composite structure.

difference in melting points which makes fusion or spot welding a problem.

The Alcres process, developed by the South Wind Division of Stewart-Warner Corp., has opened a new avenue for joining dissimilar metals. Alcres is a special type of brazing, between aluminum and steel in a closely-controlled furnace at about 1100°F; this is the flow temperature of the brazing alloy. The resulting bond is gas- and liquid-tight; it is also resistant to instant thermal shock from —320 to 400°F. Strength of bond in tension is greater than that of the parent aluminum up to 760°F.

This technique has been successful in the design of aircraft fuel pre-heaters; good corrosion resistance, high internal pressure, and 30 per cent weight-saving were obtained. In this case, the internal core of the pre-heater structure was of stainless and the exterior shield of aluminum. Additional lightening resulted from welding aluminum valves and plumbing to the shield.

Service Condition Tests

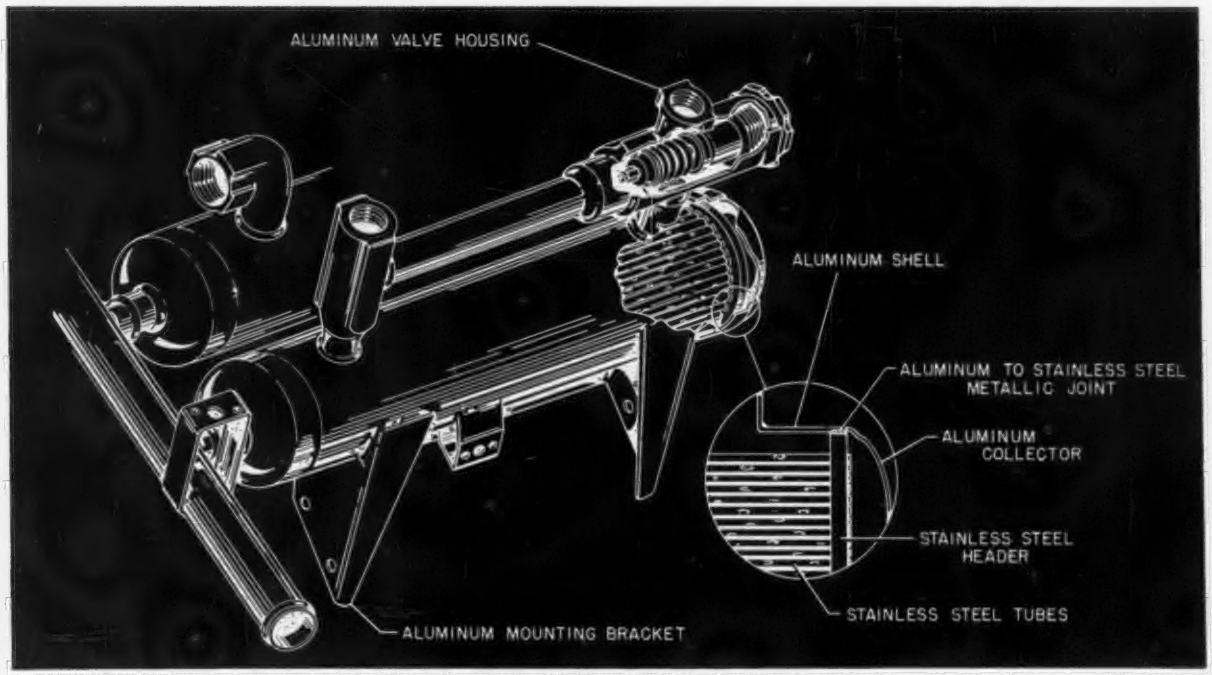
Two composite stainless-aluminum cylinders were brazed by the Alcres process for testing (Fig. 1); type 347 stainless and 3003 aluminum were used, both of 0.030-in. thickness. The cylinders were first leak-tested at 10 psi through the adapters shown at the top. Then, both cylinders were subjected to pressure and thermal cycling. The temperature range extended from —65 to 500°F; internal pressure was maintained at 20 psi. After 1224 cycles cylinders were again subjected to leakage tests; no failure of the braze joint was evidenced.

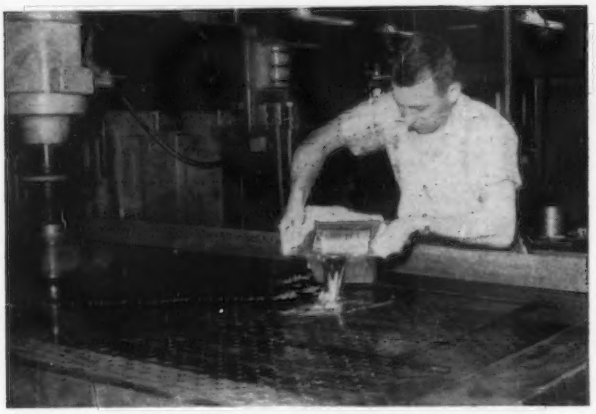
Next, the cylinder at the right was subjected to increasing internal pressure. Fracture occurred at 224 psi in the aluminum immediately adjacent to weld at "A." The fracture was repaired by welding and the cylinder again pressurized. At 222 psi the parent aluminum failed at location "B." After repairing the second fracture, the stainless cylinder was cut off at "C." A new welded joint was made at about ¼ in. away from the brazing, and pressure applied. A third failure resulted at location "D" after ballooning the aluminum; no leakage occurred at the braze joint in any of these tests. The cylinder on the left was subjected to low temperature shock tests in liquid nitrogen without damaging the braze joint.

In another test a stainless steel tube bundle (Fig. 2) was brazed into an aluminum shell; the assembly was successfully subjected to 50,000 pressure cycles of 0 to 60 psi at about 300°F.

Salt water immersion (MIL-F-8615) and salt-fog-exposure tests (MIL-E-5272A) indicated that the braze bond corrosion resistance was comparable to that of 3003 aluminum.

◆





Preparation of shallow Cerroloy pool on steam-heated platen.

electrolytic machining of honeycomb

anode workpiece secured in low melting alloy, rotating abrasive wheel acts as cathode; finished surface free of burrs

The paradox of current high-strength materials is nearing that of the "universal solvent"; the tougher the materials being produced, the harder the conventional machining problems are becoming.

Among the newer metal-removal processes the electrolytic method has been making noteworthy strides. This process has been particularly suitable for machining stainless honeycomb for airborne structures.

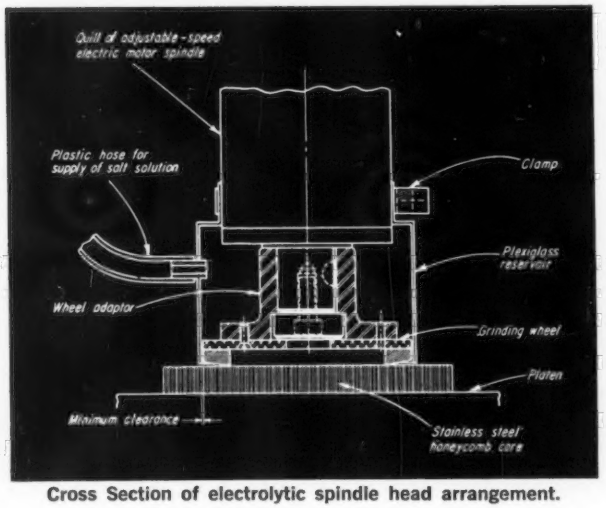
Electrolytic metal removal is based on anodic dissolution; it is a fast etching and lapping process taking place at the same time. The workpiece to be shaped becomes the anode and the grinding wheel the cathode. The rotating grinding wheel is mounted on a special spindle and is insulated from the machine body. Instead of coolant a non-toxic and non-corrosive electrolytic solution is used. The solution is fed to the grinding wheel and distributed over its face by centrifugal action. This causes metal to dissolve from the anode workpiece but to prevent deposition on the cathode. The metal-bonded abrasive wheel has particles protruding slightly beyond the metal and do the lapping; these particles also serve to space the workpiece from the metal bond of the wheel. The work is held against the abrasive wheel with an approximate gap of 0.001 in. Accordingly, high current densities are obtained which accelerate many hundredfold what would normally be a slow electromechanical process.

The abrasive particles lap or wipe away the insoluble anode-reaction products from the workpiece. Since metal is removed mostly by electrochemical action, wheel wear is minimized. Also, the workpiece generally remains at ambient temperatures.

Metal Removal Feeds

The amount of metal removed within a

Spindle close-up during grinding application. Liquid seen on honeycomb is non-toxic and non-corrosive electrolytic solution distributed by centrifugal action.



Cross Section of electrolytic spindle head arrangement.

Honeycomb in Cerroloy pool is being weighted with Kirksite blocks, prior to pool solidification by cooling.

given period is directly proportional to the amperage. In turn, amperage flow between wheel and workpiece is limited by the area of contact. Overheating and glazing present no problems in electrolytic metal removal. Therefore, the widest wheel possible for a given workpiece is used.

Metal removal speed is almost independent of workpiece hardness, providing there is sufficient electrical capacity for electrolytic attack over the entire wheel width. It is interesting to note that this process removes material from cast iron or cemented carbides at about the same rate. In most cases, a safe "rule of thumb" has been to allow one sec/in. of travel, for each 0.001 in. depth of cut.

Working with Honeycomb

A great advantage of machining stainless honeycomb electrolytically has been the smoothness of obtainable edges. Burr-free edges are particularly desirable here to promote good contact between honeycomb core and faceplates, during assembly by brazing; edge tears or layovers are undesirable.

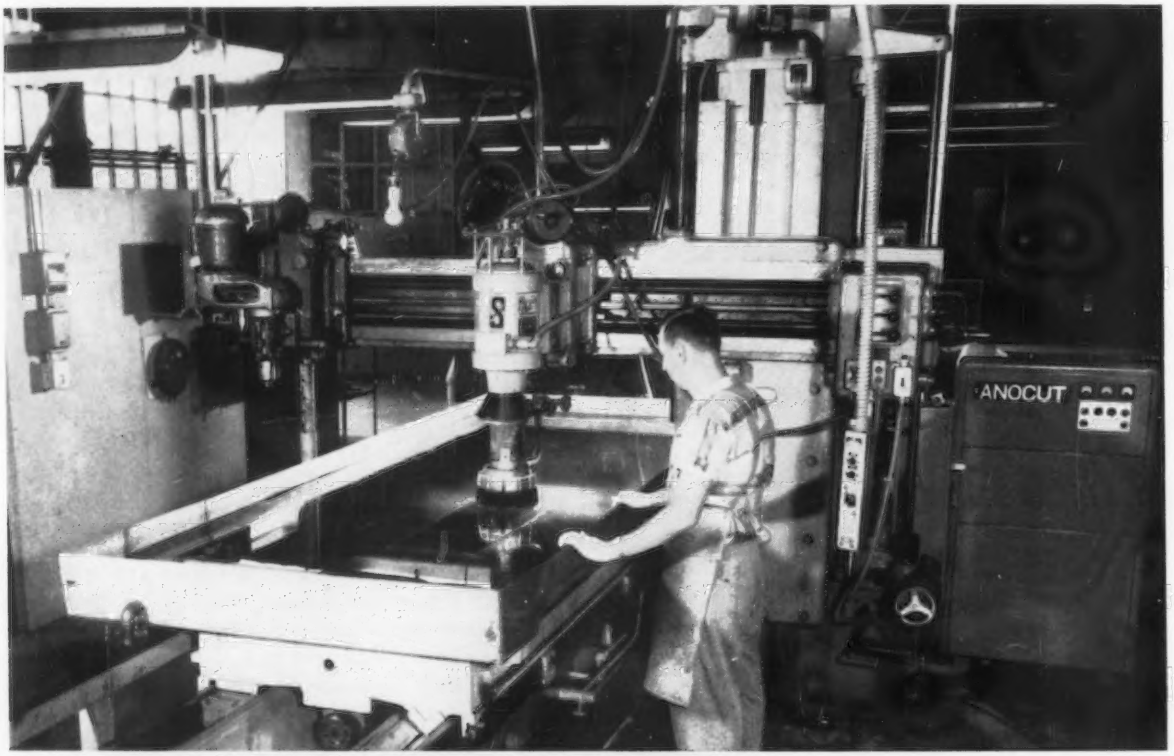
The Aeronca Mfg. Co., Middletown, O., has used this process successfully in its sub-contracting activities. As a basic unit a Rockford hydraulic open-side planer equipped with an 11 x 48 x 3½-in. meehanite cast metal platen. The platen has internal piping for heating by steam and cooling by water. The removal of metal is done by a special spindle developed by the Standard Electrical Tool Co. of Cincinnati; power is supplied by a 300 amp Anocut unit.

The 17-7 PH stainless steel honeycomb slabs used are about 15 x 39 x 0.310 in., with 0.0015-in. foil thickness. To clamp the honeycomb, steam is circulated through the platen, and on it, a ⅛-in. deep pool of molten Cerroloy is prepared. The platen has ⅜-in. deep holes, spaced

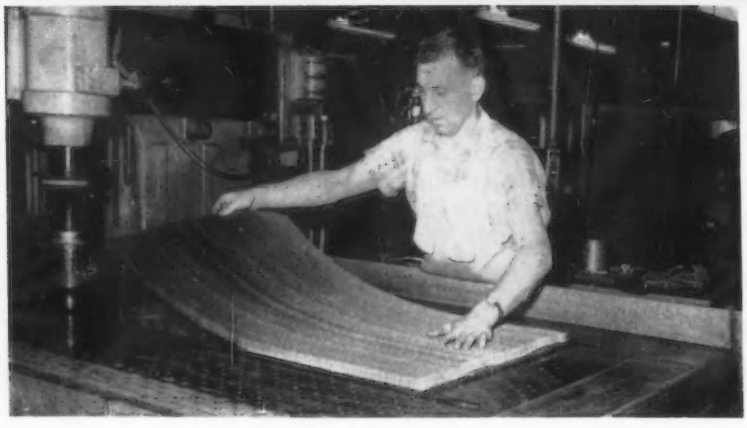
about 2 in. apart, to provide a firm lock between platen and Cerroloy upon cooling. After positioning the honeycomb, Kirksite block weights are gently placed on the honeycomb. The steam is then turned off and cold water is circulated through the platen till the Cerroloy has solidified. The honeycomb is thus firmly secured to the planer table, and is ready for machining.

The Standard electrolytic spindle has variable speeds from 2400 to 4600 rpm. For this machining operation a spindle speed of 3500 rpm is used with a planer-bed travel of 24 in./min. The grinding wheel is a 6-in., aluminum oxide, Anocut bonded wheel. The machining process involves indexing 3 in./pass (using one-half of the 6-in. diam wheel); several 0.030-in. cuts are made first for the rough cutting then a 0.005-in. pass is used for finishing.

After completion of machining, steam is again run through the platen and the honeycomb freed from the table. It takes about five minutes to affix the honeycomb slab to the platen, and considerably less to remove it after machining.



Rockford hydraulic openside planer equipped with Standard electrolytic spindle grinder head. Anocut power unit at right supplies 300 amp DC current needed for operation.



After grinding operation, steam is re-circulated through the platen, and the finished honeycomb core is freed from planer table. Cross section of electrolytic spindle head arrangement.

AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

DESIGN

ARGOSY—A.W.A.'S NEW TRANSPORT. W. T. Gunston. *Flight,* (October 1958), 10 pp. Extensive description of background and design details of Armstrong Whitworth AW. 650 Argosy, with cutaway drawings.

BLACK KNIGHT—AN INSPECTION AND SOME DEDUCTIONS. J. H. Stevens, *Flight,* (October 1958), 3 pp. A discussion on the project, the launching site, and the vehicle.

SUPERSONIC ASPIRATION. A. R. Weyl. *Aero.,* (November 1958), 4 pp. Design of air intakes and diffusers for supersonic aircraft and hypersonic wind tunnels discussed.

EXPERIMENTAL MODEL TECHNIQUES AND EQUIPMENT FOR FLUTTER INVESTIGATIONS—A SURVEY OF BRITISH PRACTICE. W. G. Molyneux. *Acft. Eng.,* (November 1958), 6 pp. An outline of the uses of flutter models as an aid to the designer in to avoid flutter.

WHAT ARE THE SAFETY HAZARDS OF NUCLEAR PROPULSION? L. Seren. *Space-Aero.,* (November 1958). Problems of crash protection, overheating, and heat production after shutdown presented.

STRUCTURAL AIR. *Mach Des.,* (November 27, 1958), 4 pp. Applications given for inflatable sandwich design.

SEASLUG—THE MOST MISSILE IN THE LEAST SPACE. W. T. Gunston. *Flight,* (November 21, 1958), 5 pp. Development and design features of British ship-to-air missile given.

MATERIALS and PROCESSES

NOW YOU CAN SPECIFY PLASTIC PRESSURE VESSELS. A. J. Wiltshire. *Matls. in Des. Eng.,* (November 1958), 4 pp. Information on types, designs and uses, as well as criteria for comparison with steel and aluminum vessels.

THREE NEW WAYS TO MAKE PRECISION FORGINGS, EXTRUSIONS. J. F. Murphy. *Matls. in Des. Eng.,* (November 1958), 3 pp. Rotary forging, precision forging of gears, and cross extrusion techniques are discussed and current applications given.

RUDDER SHAFTS FOR MISSILES MADE IN HALVES AND WELDED. R. Meredith. *Mach.,* (November 1958), 3 pp. Application of Inconel "X" to a component intended for high-temperature operation.

COMPLEX SHAPES ARE CONTOUR ROLLED IN EXPENSIVE MATERIALS. F. J. Altmann and R. D. Libert. *Amer. Mach.,* (November 3, 1958),3 pp. Materials, methods and advantageous applications presented.

WIDE-GAP BRAZING ALLOY ASSEMBLES ENGINE RINGS. R. C. Kellner. *Amer. Mach.,* (November 3, 1958), 2 pp. Brief description of high-temperature nickel-base alloy brazing application to jet-engine component.

PLASMA ARC TORCH USHERS IN NEW FABRICATING, COATING METHODS. *Iron Age,* (December

continued on next page

4, 1958), 2 pp. Process for the application of metallic and nonmetallic coatings shows promising uses for missile components.

PRODUCTION

NON-DESTRUCTIVE TESTING (PART III). *Acft. Prod.*, (November 1958), 13 pp. Use of dye and fluorescent penetrants discussed, as practiced at Vickers Armstrong.

DRAW DIE FORMS TAPERED PARTS. C. Myers. *The Iron Age*, (October 9, 1958). 2 pp. Boeing technique described for draw-forming and stretch-straightening material with non-uniform cross section.

ROCKET-ENGINE MANUFACTURE REQUIRES MACHINING INGENUITY. C. O. Herb. *Mach.*, (September 1958). 6 pp. Description of representative machining operations practiced at the liquid-rocket plant, manufacturing division of Aerojet-General Corp.

ROTODYNE ROTOR-BLADE (PART I). *Acft. Prod.*, (November 1958), 6 pp. Heat-treatment and machining operations on the high-tensile steel main spar are discussed.

BOOKS RECEIVED

CERAMIC FABRICATION PROCESSES. W. D. Kingery. *Wiley & Technology Press M. I. T.*, 1958. 235 pp. $9.50. This book is written by 22 ceramic scientists from industry universities and research organizations. It deals with basic and advanced concepts of ceramic structures from a materials standpoint; offers comprehensive coverage of fabrication techniques. It also provides sound information for selecting, forming, and joining of conventional ceramics, ferrites, ferroelectrics, and glass-ceramics.

MAN, METALS, AND MODERN MAGIC. J. G. Parr. *American Society for Metals*, 1958. 238 pp. $2.95. A very readable non-technical booklet telling the story of metal technology and its influence on civilization.

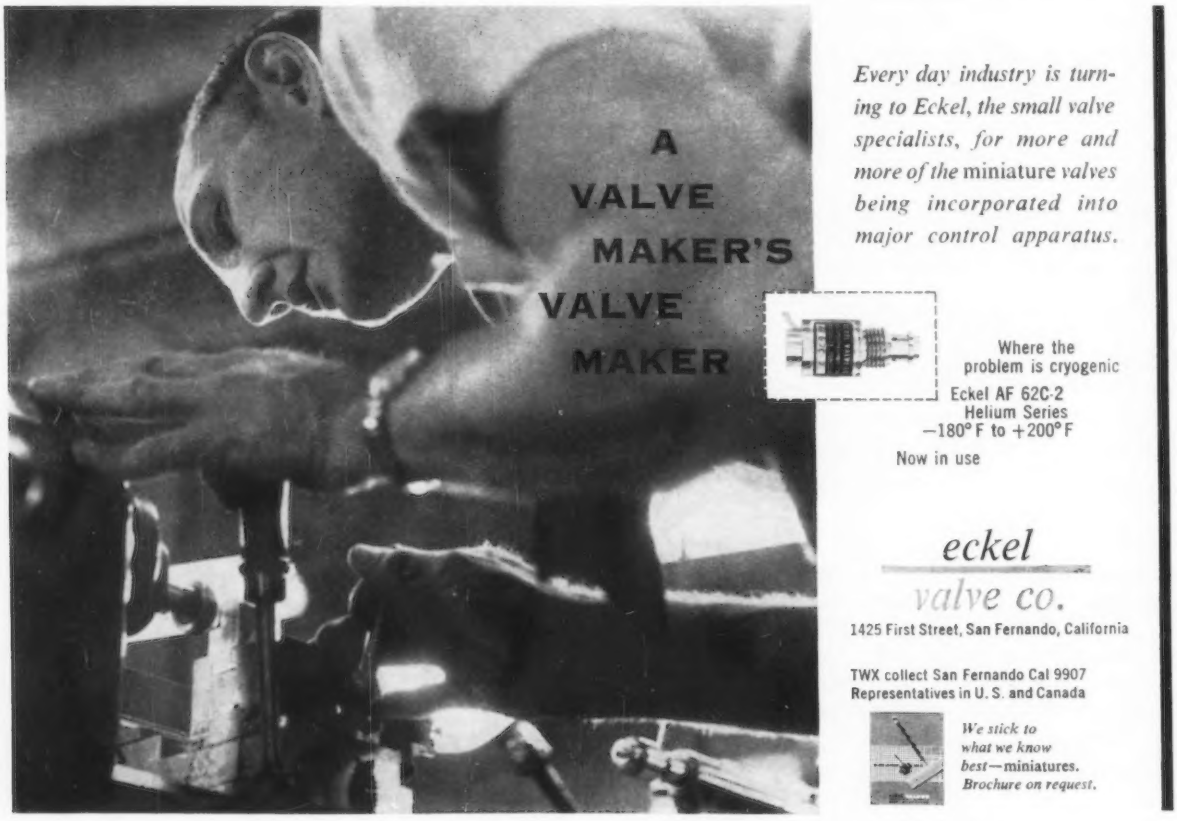
REVIEWED IN THIS ISSUE

Periodicals and Papers

Aero. Aeronautics (British)
Acft. Eng. Aircraft Engineering (British)
Acft. Prod. Aircraft Production (British)
Amer. Mach. American Machinist
Flight Flight (British)
Iron Age The Iron Age
Mach. Machinery
Mach. Des. Machine Design
Matls. in Des. Eng. Materials in Design Engineering
Space-Aero. Space Aeronautics

Books Received

Ceramic Fabrication Processes Wiley & Technological Press MIT
Man, Metals, and Modern Magic American Society for Metals


A
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Every day industry is turning to Eckel, the small valve specialists, for more and more of the miniature valves being incorporated into major control apparatus.
Where the problem is cryogenic
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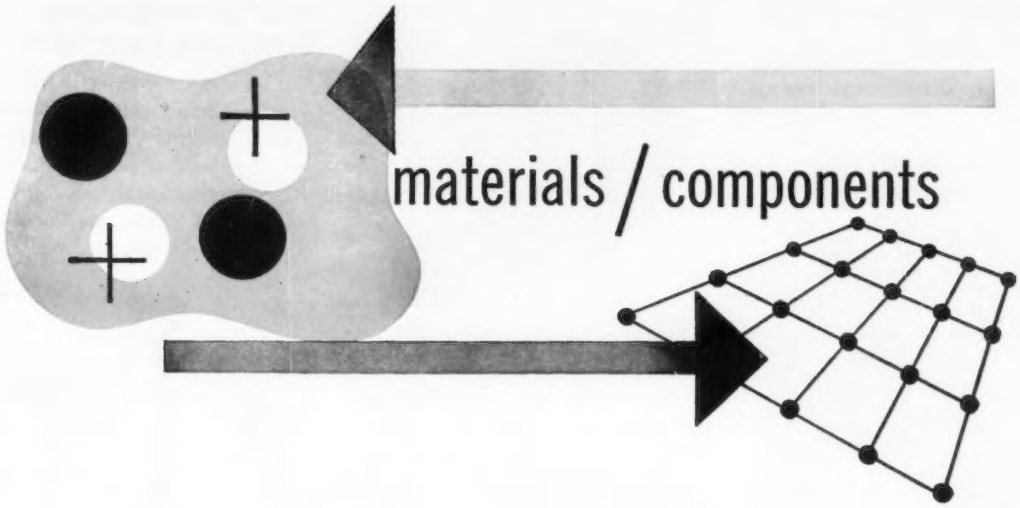
Representatives in U. S. and Canada
We stick to what we know best—miniatures. Brochure on request.



ZIP-ON COATING PROTECTS WIRE BUNDLES

Zippertubing is wrapped around a wire bundle, then zipped shut by means of an attached metal or plastic track. At the point of a branchout, the wires are split into various channels and a Y or T zipped around them. Zipper end bells also are available to cover and protect connectors.

The junction of the Y or T to the rest of the cable is accomplished with high temperature tapes or potting compounds. When the potting method is used, the Y or T serves as a flexible mold and the compound is poured inside.

The Zippertubing Co.
Circle 75 on postcard for more data

FIBROUS $K_2Ti_6O_{13}$ SUITED TO ROCKET INSULATION

Fibrous potassium titanate appears suited for insulating applications where space and weight are critical. In the 1300 to 2100°F range, it is about twice as effective on a volume basis as most insulating material.

It may offer construction advantages for rockets and missiles, aircraft and atomic-powered vehicles. Suggested, but as yet untried, uses are: insulation for missile nose cones, and use in rocket combustion chambers.

An important advantage is ease of fabrication. Presently available forms include loose fibers, loose fill, blocks of varying densities, mats of various thicknesses, and "lumps." Also available is a trowelable material which, when combined with water, can be spread onto almost any irregular surface like mortar.

E. I. DuPont de Nemours & Co.
Circle 77 on postcard for more data

SNAP ACTION SWITCH HAS LOCK-OUT FEATURE

A safety lock-out feature is now available in the toggle-actuated snap action switches.

This feature prevents accidental switching of a double-pole double-throw unit to a potentially dangerous position. It is particularly applicable to switching of aircraft instrument control circuits. In order to move the toggle to its position off neutral, the operator must raise or pull out the toggle handle. The toggle can be moved to the opposite direction—usually a momentary position—without this safeguard.

The new switching action is available on DPDT high sensitivity switches affording four

different switching combinations.

Milli-Switch Corp.

Circle 80 on postcard for more data

JET ENGINE STARTER USES AIR OR EXPLOSIVE

Two-in-one jet aircraft engine starter powered by either compressed air or a propellant charge was designed for Republic F-105.

Unique feature of the starter is its double face turbine wheel. Conventional vanes take bleed-air and spin the turbine wheel to produce up to 100 horsepower to start a main jet engine.

Also contained in the same wheel are impulse turbine buckets which produce over 100 horsepower when operating on propellant gases. During attack or practice scramble, a pilot at the push of a button electrically fires a solid propellant charge. During this firing period the wheel's front-face vanes act as a fail-proof aerodynamic brake controlling overspeed.

The Garrett Corp.

Circle 79 on postcard for more data

LOX OR FUEL LEVEL MEASURED ACCURATELY

Airborne servo transducer system designed for the continuous measurement of LOX or fuel head in missiles is in production.

Based on a force-balance servo system, unit is to measure the height of a column of liquid within very close tolerances. Typical values for a 22 ft column are: repeatability 0.040 in. and hysteresis 0.080 in. Normal LOX boiling will not cause erroneous readings.

Designated Leonard model 502400-2, this new system features two potentiometer outputs, one fine the other coarse.

W. O. Leonard Inc.

Circle 81 on postcard for more data

GANG POTENTIOMETER USES PLASTIC, STAINLESS

Design of this gang potentiometer unit makes possible phasing and rephasing of individual resistance wipers without disturbing resistance settings of adjacent cups.

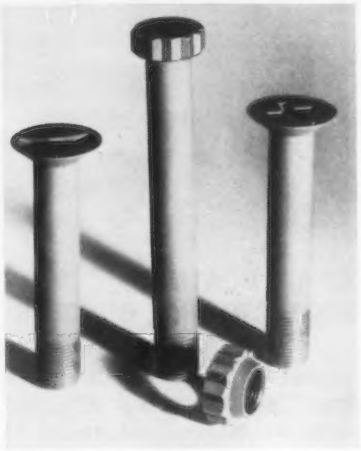
Potentiometer is manufactured of a high temperature plastic case, and stainless steel mounts and ends.

Daystrom Pacific Potentiometer Div.

Circle 78 on postcard for more data

FASTENERS COMBINE STRENGTH, LIGHTNESS

High-strength shear bolts, up to 71 per cent stronger than currently used aircraft counterparts, are shown here in three conventional 100-deg flush-head types with Hi-Torq and Torq-Set drives, respectively.



New 12-point external wrenching locknut completes the high-strength joints just introduced.

Standard Pressed Steel Co.

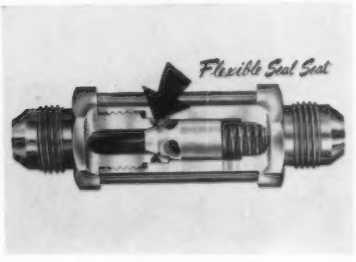
Circle 76 on postcard for more data

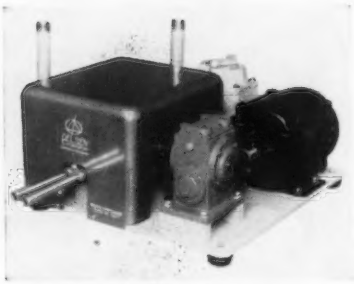
CHECK VALVES ARE SPRING LOADED

Spring-loaded hydraulic and pneumatic check valves are engineered and tested to withstand high shock. They retain leak-tightness, positive action at very low pressure, full flow with low pressure drop, freedom from vibration and chatter. There are six standard Dryseal pipe and JIC tube sizes and 12 connection combinations, all available from stock.

Kepner Products Co.

Circle 82 on postcard for more data





RESIN DISPENSER

A positive displacement resin dispenser is available for use with liquid resin and hardener systems. Accurately calibrated to meter both liquid hardeners and resin in exact proportions, it has eliminated the necessity for time consuming weighing operations in plastic fabricating plants.

The resin material is accurately metered through drip-proof valves. Both hand-driven and motor-driven models are available. Motor-driven units are available either with or without explosion-proof housings on the motor and switch.

The Delsen dispenser unit, used by companies employing liquid resins in aircraft and missile equipment, will function satisfactorily for most two-component adhesive and coating systems.

Delsen Corp.

Circle 86 on postcard for more data

TESTS CAPACITORS FOR RELIABILITY

Reliability factor of capacitors over a given temperature range can be checked with new precision capacitance and temperature coefficient tester.

Self-contained unit measures capacitance and temperature coefficient over range from —65° to +175°C.

Accuracy of temperature setting is ±5°C, with maximum variation from the setpoint of ±1°C. Rate of temperature change is 2.5° per minute.

Systems Engineering Div.
Paul Hardeman, Inc.

Circle 85 on postcard for more data

TV SYSTEM ADJUSTS TO CHANGING LIGHT

Built-in automatic light adjustment control is special feature of this closed-circuit TV system.

Model 1986 adjusts to variations in light level up to 1000:1. Its adaptability is most apparent when lighting conditions are subject to rapid change. Optimum visual performance can be maintained at all times.

Camera, used with Control Unit, provides up to one volt output at 10 foot candles.

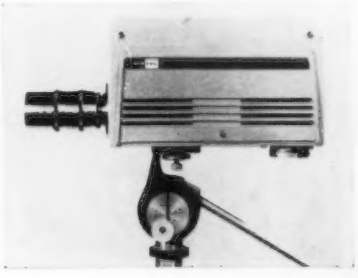
Monitor in the system has a 14-in. aluminized picture tube. Picture brightness is assured by Polaroid filter and a second anode voltage of 16,000 volts. A white clipper circuit automatically provides optimum definetion when viewing extremely bright objects.

A high-efficiency cast heat-sink in the camera provides long, tube lift, continuous operation in ambient temperature up to 65°C. The Camera Control Unit, blower cooled, can operate continuously in 55°C ambient temperatures.

Bandwidth of the video amplifier is 8 megacycles, ±0.5 db. A transistorized, ultra-stable, full countdown sync generator provides EIA standard pulses, either crystal controlled, line locked, or free running.

Kin Tel Div.
Cohu Electronics, Inc.

Circle 93 on postcard for more data



MACHINE ENLARGES MICROFILM DRAWINGS

The Copytron Model 1000 makes working size enlargements of 35 mm microfilm drawings and records.

Machine uses an electrostatic reproduction process, doing away with conventional developing solutions or baths.

A finished print, up to 18 in. x 24 in., of a microfilmed engineering drawing is delivered about 30 sec after a ten sec exposure.

Charles Bruning Co.

Circle 91 on postcard for more data

The further we progress,
the more important
experience becomes in solving
today's most urgent problems.

ECM (X)

One company actively and continuously
engaged in advanced ECM research
and development
since 1952 is . . . hallicrafters

4401 W. Fifth Ave., Chicago 24, Ill.

SERVICES—research and development
• electronic equipment production
• reliability evaluation
EQUIPMENTS—communications • radar
• countermeasures • reconnaissance
• infra red devices • heat exchangers
• pulse generators • antennas

WELDING GUN "STAPLES" THERMOCOUPLE WIRES

Press the tip of this portable welding gun against a thermocouple wire; push a button, and wire is welded in place. Made especially for rapid spot-welding of thermocouple junctions and similar light assemblies, welder consists of a welding gun, connected by a cable to a transformer and holster suspended from the operator's shoulder.

A longer cable (200 ft) connects portable equipment to a control console which contains the two-channel weld sequence circuit and a pneumatic system for controlling the weld and forge pressures applied by the gun. In contrast to conventional condenser-discharge welders, the model 4032 employs ignitron power control circuits for precise control of weld current.

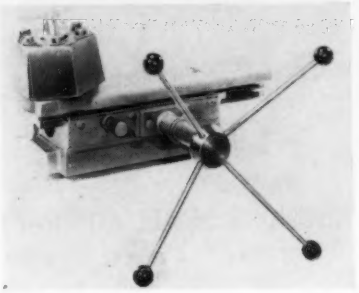
Research, Inc.

Circle 94 on postcard for more data

BED TURRET USED FOR LARGE LATHES

Self-indexing extra heavy duty A. K. bed turret converts engine lathes into ram-type turret lathes for multiple machining.

Designed for large lathes in the 13 to 16 in. range, bed turret has six station meehanite head. It is produced in two models, straight ram or tilt head ram (5° angle). Latter, allowing greater clearance over ram, permits use of larger tools.



Blank tool holes can be machined for perfect alignment with spindle hole.

Precision Processing Co.

Circle 84 on postcard for more data

ACOUSTIC NOISE GENERATOR

A new electromechanical loudspeaker producing up to 166 decibels of random noise has been developed for acoustic noise testing of missile and rocket components and systems.

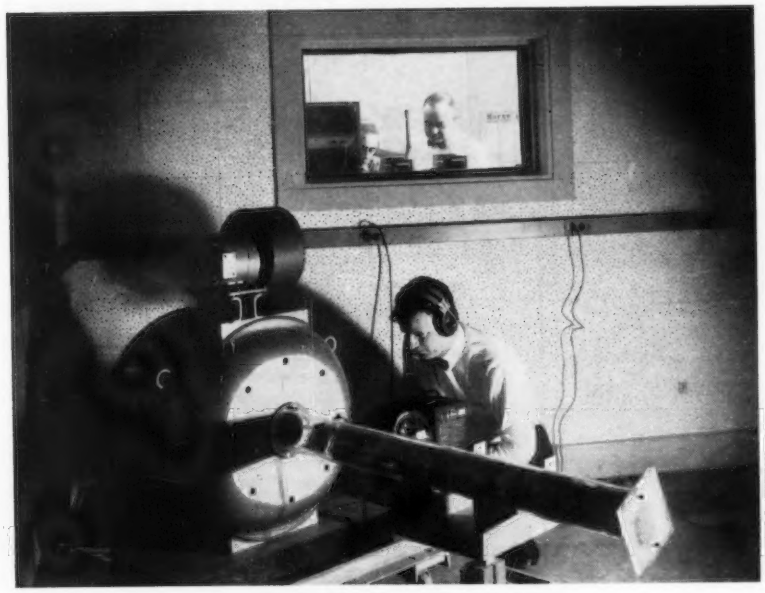
The loudspeaker is an electromagnetic unit with a 12-inch-diam moving coil. The generator was designed for compatibility with the electronic power supplies and control consoles now being used with vibration test equipment. Heart of the unit is the plastic and fiber glass reinforced moving coil diaphragm assembly, suspended by U-shaped beryllium-copper springs from the electromagnetic housing. The acoustic energy produced by the diaphragm is focused and sent through an expanding horn to a four-inch-diam opening in the speaker structure.

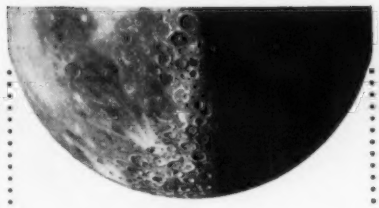
A component or small system under test is placed in a progressive wave tube between the generator and the absorbing material. For larger component or systems the material is placed in a reverberant chamber.

The generator is 35 in. high, 24 in. long and 26 in. wide.

Avco Research and Advanced Development Div.

Circle 89 on postcard for more data





A message
of importance to
Design and Research
ENGINEERS

Our Gas Generator and Combustor System Group designs and develops components for large rocket engines. These career jobs are waiting for the right men:

Design Engineers to design and develop gaskets and seals for liquid propellant rocket engine flow systems that involve extremes of high and low temperature, high pressure, and corrosiveness. Must be capable of originating designs, planning and conducting test programs, analyzing test data, and preparing written reports on results. Background: BS in mechanical or chemical engineering—plus a minimum of 5 years experience in design and development of mechanical components, preferably for fluid flow systems.

Design Engineers with experience in high-temperature design, such as in combustion devices or boilers. He should be familiar with military and aircraft standards.

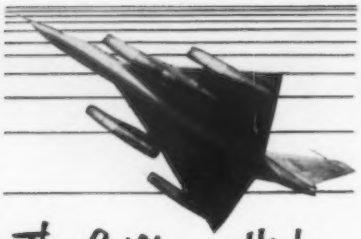
Research Engineers to conduct developmental programs on gas generators and combustors. Must be able to specify instrumentation, evaluate data, make practical equipment change recommendations—and work with a minimum of supervision. Experience should be with development of combustion or similar high-temperature equipment.

Please write to Mr. K. A. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, Calif.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.
FIRST WITH POWER FOR OUTER SPACE

Circle 31 on Inquiry Card, page 81



The Ceiling is Higher

in opportunity, too

. . . at GE's

JET ENGINE DEPT. in CINCINNATI

If you like to meet and solve new problems . . . if you like the challenge of the unknown . . . if you're a man who likes to help write tomorrow's textbooks in today's test labs . . . if you don't know that "it can't be done that way" . . .

you'll like it at GE . . . where a man's ability is recognized and rewarded.

Our unique use of small-unit work groups emphasizes and encourages creative freedom. Our engineering staff has more than doubled since 1955, and annually about 50% of our engineers have been promoted.

Right now the high energy fuel jet engine of the future is being developed. Top men in the industry want you to join them in this exciting pioneering at General Electric. Career positions for *Degree Engineers with U. S. Citizenship* are open in many fields—

RELIABILITY ANALYSIS . . . AERODYNAMIC DESIGN—COMPRESSORS, TURBINES . . . ELECTRICAL CONTROLS DESIGN . . . ADVANCED ENGINE PERFORMANCE ANALYSIS . . . ENGINE FLIGHT TEST . . . CONTROL COMPONENT DESIGN . . . COMBUSTION SYSTEMS DESIGN . . . ENGINE MECHANICAL COMPONENT DESIGN and many others.

Send your resume—or, for more information, write or phone:

Mark Elwood, General Electric Co.
Jet Engine Dept. AM-159
Cincinnati 15, Ohio
Phone POplar 1-1100

Collect long distance calls will be accepted any weekday 9 A.M.-4 P.M.

GENERAL ELECTRIC

Circle 32 on Inquiry Card, page 81

ANCHORS SMALL AIRCRAFT

"Ezy," a screw type device, ties down small aircraft tarpaulins, other objects. Cast iron tool, 15 in. long, can usually be locked into earth in a minute.

Van Dyke Industries

Circle 83 on postcard for more data

LOW-COST TORQUEMETER

New torquemeter covers ranges from 5 to 250 oz.-in. full scale. It measures dynamic torques on shafts turning between 50 and 12,000 RPM with an accuracy within 2 per cent of full scale. Linear scales and simple calibration minimize operator error.

Torque readings are independent of shaft speed and direction of rotation. Simple calibration adjustment provides stability against ambient changes and internal aging effects.

For remote readings, indicator may be located conveniently and connected electrically to be compact torque pickup.

Metron Instrument Co.

Circle 92 on postcard for more data

Aircraft and Missiles Manufacturing is read by the key design, engineering, production and procurement men in plants producing aircraft, missiles, power plants, and parts.

A STANDBY ENGINE

Automatically Controlled

by SYNCHRO-START CAN PROTECT YOU FROM MAIN POWER FAILURE

In A Matter of Seconds power can be re-established by a standby engine equipped with Synchro-Start controls.

Since 1932 Synchro-Start has been manufacturing dependable controls that are operating standby power engines to provide protection for . . .

- HOSPITALS
- AIRPORTS
- PUMPING STATIONS
- PIPE LINES
- ELECTRIC PLANTS
- BRIDGES
- COMMUNICATIONS
- MILITARY CENTERS

AND MANY OTHERS

These controls are in world-wide use plus a variety of other controls manufactured for specific engine operations.

For complete information on your requirement send engine data and desired operational control.

SYNCHRO-START PRODUCTS, INC.

Since 1932

8151 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

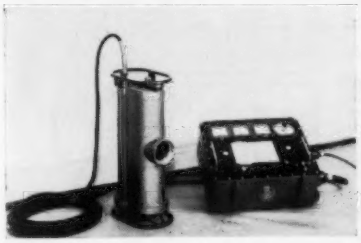
Circle 33 on Inquiry Card, page 81

X-RAY EQUIPMENT GIVES CLOSE ACCURACY

Low, medium, and high voltage radiography for nondestructive testing of aircraft and missiles is obtained from this industrial X-ray equipment.

Manufactured by Rich. Seifert & Co., Germany, line includes oil and water cooled Isovolt units. These incorporate constant potential voltage smoothness principle for examining steel from two in. to 5¼ in.

Also being marketed:



portable heavy-duty Eresco, MS or X-Tron Series units for 360° circumferential or 40° single port X-ray examination.

Mitchell Radiation Products Corp.

Circle 87 on postcard for more data

3D MAGNIFIER AIDS LAB TECHNICIANS

A new binocular-type magnifier, called Magni-Focuser, helps electronic technicians study intricate systems.

Matched optical glass lenses are mounted in a plastic eyeshade with adjustable headband. This leaves both hands free. Focuser can be worn with or without regular eyeglasses.

Edroy Products Co.

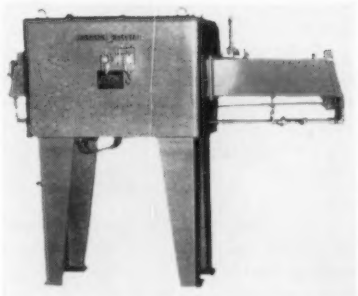
Circle 90 on postcard for more data

NEW LAB-TYPE BOX FURNACE

A new laboratory-type box furnace designed to meet precise requirements for extremely high, automatically controlled temperatures in a protective atmosphere has been introduced.

The double-end, through-type furnace is designed for copper and silver brazing of metals, metallic oxide reduction, melting metals, powdered metal sintering and bright annealing of metals.

Built by the company's Industrial Heating Dept., Shelbyville, Ind., the new unit permits materials to be cooled in a protective atmosphere. It obtains precision automatic temperature control by radiation detector.



The heating chamber, lined with purity brick suitable for operation up to 3200 F, is designed with throats at both ends to permit slow heating and cooling of the charge. A manually operated sliding door separates the cooling and heating chambers.

General Electric Co.

Circle 88 on postcard for more data

ELECTRO-MECHANICAL ELECTRONIC ENGINEERS

A BS or advanced degrees in EE, ME, or Physics, may qualify you for a career at NAA, home of the advanced B-70, F-108, and X-15.

Flight Control Analysis, Reliability Analysis, Flight Simulation, Systems Analysis.

Electrical Systems Analysis and Design, Mission and Traffic Control, Fire Control, Bombing Systems, Electronics Systems Integration, Flight Controls, Ground Support Equipment, Airborne and Electronic Test Equipment.

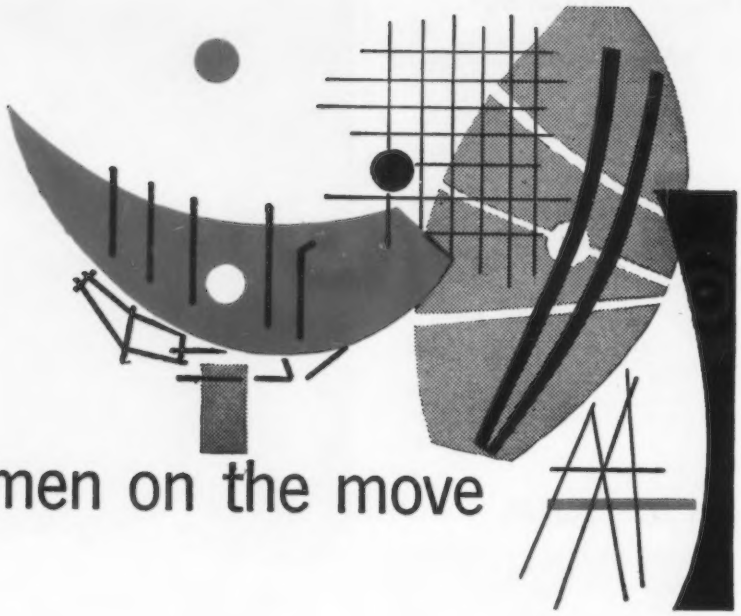
Applied Research in Radome Development, Antenna Development, Infrared, and Acoustics.

Please write to: Mr. L. A. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

Circle 34 on Inquiry Card, page 81



men on the move

Henry Correa
ACF Inudstries

John H. Zillman
Daystrom Pacific

HENRY A. CORREA elected vice president of marketing for ACF Industries, Inc.

JACK H. ZILLMAN appointed general manager of Daystrom Pacific.

JOHN H. MAIN will be design superintendent; WILLIAM J. RUE will be production superintendent at the new Solid Propellant Plant of Hercules Powder Co., Bacchus, Utah.

C. T. RAY now heads the new Commercial Products Dept., Baltimore Div. of the Martin Co.

W. R. CLAY appointed assistant to the vice president of engineering at the Radioplane Div., Northrop Aircraft, Inc. WARD B. DENNIS appointed corporate director of development planning.

DR. RUBEN F. METTLER appointed executive vice president and general manager of Space Technology Laboratories. WILLIAM M. DUKE appointed director of the System Engineering Div.

CHARLES J. GALLANT elected executive vice president, North American Aviation, Inc. GERALD B. BROPHY, R. A. LAMBETH, J. S. SMITHSON, and LAURENCE L. WAITE elected senior vice presidents. ED COKELEY named director of the firm's Flight Test operations at Edwards Air Force Base; DR. EDGAR L. ARMI now chief, research staff, Autonetics Div.

C. T. Ray
Martin

W. R. Clay
Northrop Aircraft

William M. Duke
Space Technology Labs.

Dr. Edgar L. Armi
Autonetics

R. O. WOLCOTT named director of administration for Aeronautical Div., Minneapolis-Honeywell Regulator Co.

DAN W. BURNS and ROBERT T. CAMPION elected vice presidents of The Siegler Corp.

JAMES H. DUNBAR, JR. president Dunbar Kapple, Inc., elected chairman of the board, General American Industries, Inc.

JOHN L. TAGGART joined American Bosch Arma Corp. as director of marketing.

WILLIAM F. RIORDAN appointed technical liaison manager of Buffalo Operations, Sylvania Electric Products, Inc.

GARVIN A. DREW, appointed general manager, Schrader Div., Scovill Manufacturing Co. SELDON T. WILLIAMS, elected president and general manager. RUSSEL C. FLOOD, named vice president.

J. KATZEN named manager of systems design and integration, Missile and Space Vehicle Dept., General Electric Co.; L. L. FARNHAM named manager of vehicle engineering; E. FTHENAKIS manager of navigation and control; J. HUNGERFORD manager of ground support; C. BOTKIN manager of nuclear ordnance projects; ARTHUR G. WOODSIDE appointed manager of new aircraft instrument product section, West Lynn, Mass.

BYRON L. SADLER has joined the Rosemount Engineering Co. as sales manager.

ARTHUR W. VANCE named head of information processing research dept., Hughes Aircraft Co.

NEIL McCORMICK appointed operations manager, Systems Management Office, Boeing Airplane Co. AIRO M. GONELLA named manager of sales and service dept. T. E. GAMLEM became assistant general manager—transport Div.

JACQUES R. T. DU PONT elected treasurer, Omega Aircraft Corp. HARRY P. WHITNEY, II, named chairman of executive committee.

WALTER VENGHAUS appointed vice president—operations for industrial Acoustics Co., Inc.

JAMES T. THORP, JR. engaged as chief engineer, Lambert Engineering Co.

HAROLD L. RODGERS, JR. appointed vice president at Titanium Fabricators, Inc.

CAPT. MARTIN W. MASON, U.S.N. (ret.) joined the Allison Div. of General Motors as manager, liaison—Navy. HERBERT L. KARSCH named planning director, missiles systems for the division.

ALBERT F. W. PARR elected vice president and appointed chief engineer, Power-tronic Systems, Inc., new subsidiary of Hydra-Power Corp.

H. E. RUEHLEMANN appointed vice president in charge of engineering, research, and development, Elco Corp.

WILLIAM P. PATTERSON named vice president and general manager, United Electrodynamics.

CHARLES A. NAEGELI, JR. appointed chief engineer, propellant-actuated devices, Missile Products Div., Beckman and Whitley, Inc.

DR. RODERIC M. SCOTT now directs development of photo reconnaissance equipment for Perkin-Elmer Corp.'s Engineering and Optical Div.

E. WILLIAM PLACE becomes vice president and chief engineer of Holex, Inc.

WILLIAM G. KEY has returned to Fairchild Engine and Airplane Corp. as director of public relations after serving a year as adm. asst. to Vice President Nixon.

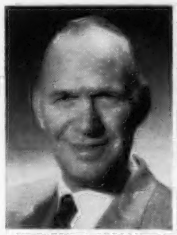
DONALD H. ADLER joined staff of Pacific Automation Products Inc., as assistant to general manager.

GRADON F. WILLARD appointed manager of the Navy HiCal Plant under construction by Callery Chemical Co., Pittsburgh.

GARETH W. SPEER named vice president-finance of Solar Aircraft Co. ARMIN F. RAEBEL promoted to chief experimental engineer. BRUCE A. WILLSEY becomes vice president and general manager of the Des Moines Div.

James T. Thorp, Jr.
Lambert Engineering

Harold L. Rodgers
Titanium Fabricators


Capt. Martin W. Mason
USN (ret.)
General Motors

Albert F. W. Parr
Power-Tronic Systems

William P. Patterson
United Electrodynamics

Charles A. Naegeli, Jr.
Beckman & Whitley

Dr. Roderic M. Scott
Perkin-Elmer

E. William Place
Holex

William G Key
Fairchild

Donald H. Adler
Pacific Automation Products

G. F. Willard
Callery

Bruce A. Willsey
Solar Aircraft

ELECTRONICS ENGINEERS

Work on America's most advanced weapon systems

At North American Aviation, work on such top-level projects as the B-70 and F-108 weapon systems, and the X-15 manned space ship, has created unique careers with a tremendous engineering potential. Widen your horizons in these fields: Flight Control Analysis, Reliability Analysis, Flight Simulation, and Systems Analysis.

We have immediate openings in applied research on radome development, antenna development, infrared, and acoustics.

Minimum requirements are actual experience plus B.S. and advanced degrees in E.E. and Physics.

For more information please write to: Mr. L. A. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

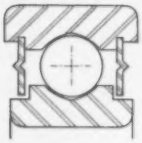
Circle 35 on Inquiry Card, page 81

EXTRA-THIN BEARING WITH BUILT-IN SHIELDS

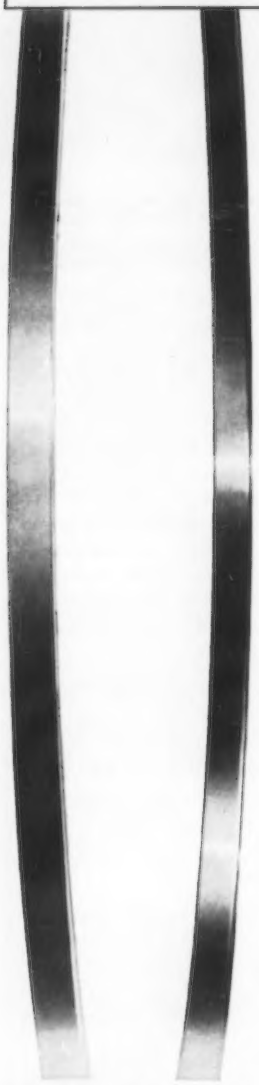
- SAVES SPACE
- SIMPLIFIES ASSEMBLY
- CUTS MAINTENANCE COST

PHOTO shows bearing ACTUAL SIZE

SECTIONAL DRAWING is 3 TIMES SIZE



SIZE: 10.500" OD; 0.270" wide; 0.250" thick.
BALL DIAMETER: 0.125" ±.000025".
MATERIALS: Stainless steel.
MAXIMUM RUNOUT OF OUTER RACE: 0.0002" TIR.
STATIC LOAD CAPACITY: Radial, 4,630 lb.; axial, 13,200 lb.
TORQUE: 5 to 6 inch-ounces at 100 lb. axial load.



Standard bearings often impose limitations on production economy and freedom of design. These restrictions are often eliminated by *special* bearings, custom-engineered by ITI. For example —

To save space, simplify assembly and prevent operating trouble, we designed and are producing this extra-thin-section ball bearing, equipped with a built-in shield on each side in place of separate shields. The shields fit so closely that they retain the lubricant and enable the bearing to pass the standard military sand and dust storm test. This construction assures long-lived low-torque operation, and cuts both assembly and maintenance costs.

YOUR design problem might likewise be simplified or your product improved by ball or roller bearings of special section or configuration, heat resistance, corrosion resistance, ultra precision, or other unusual properties. We design and produce such bearings to individual requirements, in any size from 1/4" ID to over 70" OD; and we invite your inquiries.

FREE BULLETIN AFB-2 describes our work in this field—shows a wide variety of "specials"—tells about factors involved in special bearing applications. Write for it!

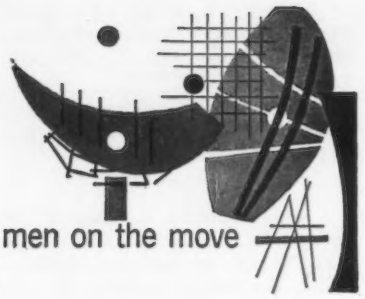
INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3668 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIF.



DAVID DOWNEY appointed assistant manager of domestic commercial sales for Convair Div., General Dynamics Corp.

WILLIAM M. FRASH joined Aerojet—General Corp. as customer relations manager for the Solid Rocket plant, Sacramento.

A. P. STUHRMAN elected director of Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp.

Z. W. PIQUE, named director of sales, Hughes Products Group, Hughes Aircraft Co.

CHARLES B. HAZZARD, JR., appointed director of marketing for Engineering and Optical Div., Perkin-Elmer Corp.

HARRY H. DOOLEY, named technical assistant to vice president in charge of sales, United States Radium Corp.

JOSEPH A. WILSON, named manager of new branch sales office in New York City, Pesco Products Div., Borg Warner Corp.

JOSEPH RAMBUSEK, JR., elected vice-president, sales, Bogue Electric Mfg. Co.

SAM N. CRAIG, appointed chief engr., Orr & Semhower, Inc.

MICHAEL H. FROELICH, named vice president, Ideax Corp.

JOHN M. RICHARD, appointed New York sales manager, Westvaco Chlor-Alkali Div. of Food Machinery and Chemical Corp. JOHN R. JACOBUCCI, named Alkali Products Mgr. ROBERT E. COCHRAN, appointed assistant Alkali Product Mgr. CHARLES E. KANEEN, assistant to sales mgr.

CLIFFORD E. WILLIS, appointed general manager, Cleveland Pneumatic Tool Div., Cleveland Pneumatic Industries, Inc.

O. L. WIGTON, named vice-president-marketing, Hancock Industries.

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Ramjet Testing

Brochure depicts testing facilities for ramjet engines at Van Nuys.

Marquardt Jet Laboratory

Circle 123 on postcard for more data

Products

Separate literature available on vibration pickup, high-speed commutator, telemetry ground stations, plexicoder, and shock testers.

Consolidated Electrodynamics Corp.

Circle 116 on postcard for more data

Nyliners

Description of Nyliner bearings and cost reduction.

Thomson Industries, Inc.

Circle 114 on postcard for more data

Sundstrand Facilities

Research, production, testing facilities described.

Sunstrand Aviation

Circle 109 on postcard for more data

Sagamore-EZ

Blue Sheet on "Sagamore-EZ Free Machining Air Hardening Die Steel."

Allegheny Ludlum Steel Corp.

Circle 118 on postcard for more data

General Mills Facilities

24-page booklet shows research in optics and other fields, structure of engineering and manufacturing departments.

Mechanical Div.
General Mills, Inc.

Circle 107 on postcard for more data

Transit Cases

Catalog describes transit cases for military protective packaging.

White Aircraft Corp.

Circle 97 on postcard for more data

Super Amides

Six-page data file on Onyx product development.

Onyx Oil & Chemical Co.

Circle 120 on postcard for more data

Tools

16-page catalog contains engineering dimensions and specifications for retaining ring pliers, applicators, dispensers and grooving tools.

Waldes Kohinoor, Inc.

Circle 127 on postcard for more data

Cryogenics

Brochure shows cryogenic, nuclear engineering and high pressure facilities.

Stearns-Roger Mfg. Co.

Circle 103 on postcard for more data

Technology: The Outlook

36-page booklet, "The Story of Technology," gives past, present, capabilities of industrial technology.

E. I. du Pont de Nemours & Co.

Circle 121 on postcard for more data

Industrial Radiography

Nondestructive testing with industrial radiography described; equipment shown.

Curtiss-Wright Corp.

Circle 117 on postcard for more data

Vibration Testing

Three bulletins give detailed specifications of vibration analysis.

MB Mfg. Co.

Circle 124 on postcard for more data

Metal Castings

Brochure describes high-strength, light metal castings for aircraft, missile, and electronic producers.

American Brake Shoe Co.

Circle 98 on postcard for more data

Fluid Controls

Bulletin describes and illustrates fluid control systems for missiles.

Koehler Aircraft Products Co.

Circle 100 on postcard for more data

Motors

Catalog EI-4 describes Elnico synchronous motors.

Electric Indicator Co., Inc.

Circle 112 on postcard for more data

Alloy Powder

Complete technical data on Alloy Powder HS 6460 for use in higher stressed parts.

Republic Steel Corp.

Circle 115 on postcard for more data

Lox and Nitrogen Converters

Six-page folder describes line of Lox and Nitrogen converters.

Linde Co.

Circle 102 on postcard for more data

Sargent Facilities

52-page brochure details history, organization, and facilities.

Sargent Engineering Corp.

Circle 108 on postcard for more data

Magnetic Shielding

31-page manual describes design and fabricating techniques for non-shock sensitive, non-retentive Netic and Co-Netic magnetic shielding.

Magnetic Shield Div.
Perfection Mica Co.

Circle 119 on postcard for more data

Wires

Booklet describes properties and applications of cold drawn fine wires.

Sylvania Electric Products, Inc.

Circle 130 on postcard for more data

Valves

Brochure on coaxial solenoid valves and applications.

Eckel Valve Co.

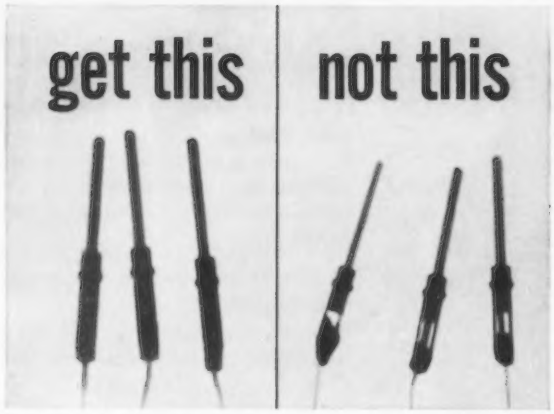
Circle 128 on postcard for more data

Converter Camera

Brochure gives details of ultra-high speed image converter cameras for study and photographic recording of transient phenomena in the microsecond range.

Librascope, Inc.

Circle 95 on postcard for more data



Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

	Conduction Method		Resistance Method	
Pin No.	Length of void	% of void	Length of void	% of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.

IDEAL INDUSTRIES, Inc. 1390A Park Ave., Sycamore, Ill.

Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

WORTH ASKING FOR . . . continued

Vertical Furnace

Plant's vertical drop-bottom traveling furnace for hardening, quenching, and tempering described in report.

J. W. Rex Co.

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Solar Capabilities

Booklet describes firm's research, development, and manufacturing activities.

Solar Aircraft Co.

Circle 96 on postcard for more data

Tracer Controls

Literature describes "Synchrotrace" automatic tracing system attachment.

True-Trace-Sales Corp.

Circle 101 on postcard for more data

High Vacuum Technology

Six-page brochure, "High Vacuum Technology and the Space Age," includes upper atmosphere vacuum spectrum chart using latest available I.G.Y. satellite data.

National Research Corp.

Circle 122 on postcard for more data

Thermocouple Probe

Bulletin describes theromcouple probe designed for high velocity gas streams over range of 2000 to 3600°F.

Thermo Electric Co., Inc.

Circle 125 on postcard for more data

Counting Devices

New Elmeg extract catalog of counting devices.

Presin Co.

Circle 104 on postcard for more data

Vibrator

12-page bulletin introduces new vibrator-concept of precision finishing.

Lord Chemical Corp.

Circle 129 on postcard for more data

Noise

Booklet on instrumentation, measurement, analysis, and control of sound.

H. H. Scott, Inc.

Circle 113 on postcard for more data

Environment Chambers

28-page brochure on controlled atmospheric conditions and environmental chambers.

Webber Mfg. Co.

Circle 99 on postcard for more data

Nuclear Engineering

New brochure, "Cryogenics, Nuclear Engineering, and High Pressure Systems."

Stearns-Roger Mfg. Co.

Circle 105 on postcard for more data

Gaging Threads

Circular describes Tri-Roll gaging comparators.

Pratt & Whitney Co.

Circle 126 on postcard for more data

Metal Fabrication

New eight-page brochure describes precision metal-fabricating facilities of Missile-Air Div.

U. S. Chemical Milling Corp.

Circle 106 on postcard for more data

Nuclear Fuels

24-page booklet, "Nuclear Fuels: Key to Reactor Performance," available.

Sylvania-Corning Nuclear Corp.

Circle 110 on postcard for more data

industry notes

BASIC RESEARCH: UNLOCKING THE SECRETS OF SCIENCE

by Peter R. Sigmund

The keys to vast realms of knowledge are held by thousands of scientists whose patient and often obscure research may extend anywhere in the universe and far ahead in time.

This is the essential "basic research" taking place in university, government laboratory, and to an increasing degree, under auspices of industrial corporations.

The aircraft-missile industry is learning that it has lots to gain from a search for knowledge as an end in itself. One definition of basic research is "finding what you need to know before you know you need it." And the industry has sometimes found itself staring at the need without too much previous "know."

RIAS Inc., a division of the Martin Co., is an outstanding example of this "research for research's sake." RIAS (taken from: Research Institute for Advanced Study) was formally organized in November, 1955. Its extreme general purposes can be seen from the charter which says, in part, that the Institute will "observe phenomena of nature and encourage, promote, and support investigations in search of underlying knowledge of these phenomena."

Idea, which has been traced back to George Trimble, Martin's vice president of engineering, was to form an organization roughly similar to Princeton's Institute for Advanced Study.

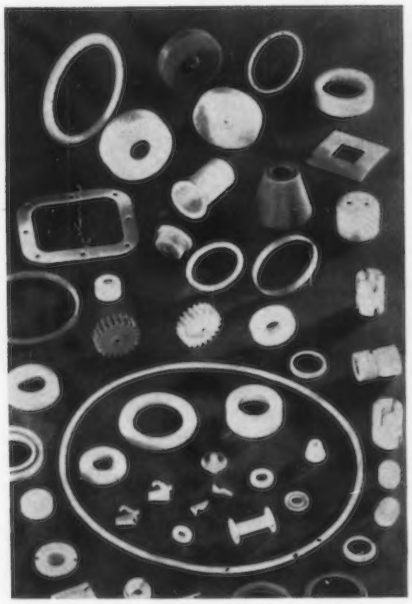
RIAS staff was formed by offering scientists opportunity for full time basic research at salaries commensurate with those paid by Martin for applied research devoted to product improvement.

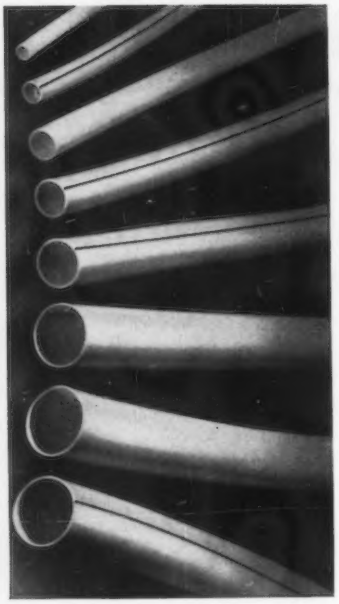
Organization exerts most efforts in the physical sciences. Interests include gravitational

THERMAL BLAST

Dr. Gerhart Groetzinger (right) and H. Hanson are shown with some of their equipment for measuring heavy primary cosmic ray particles.

If the job calls for TEFLON* use R/M and be sure!





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We understand the complexities of your problems—friction, extremes of temperature, the corrosive action of exotic fuels, etc.—and will give you all possible aid in designing, molding or machining the R/M parts or components you need. Make R/M your headquarters for all the "Teflon" products you need. Call upon your nearest R/M district office for the cooperation you require—or contact us direct.

R/M "Teflon" products for aircraft, missiles and space vehicles include thin-wall tubing (with or without identifying stripe); flexible wire braid covered "Teflon" hose; sheets, tape, rods and tubes; rods, sheets and tubes in certified and stress-relieved grades (X-ray films for sheets and rods are available); centerless ground rods held to very close tolerances.

*A Du Pont trademark

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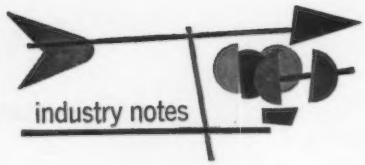
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls



field theory, theoretical chemistry, non-linear differential equations (15 RIAS scientists are working on the latter).

The idea of this type of organization seems to be catching on. In January, 1956, six scientists made up the staff. Quarters were in Martin's Middle River plant near Baltimore. Five months later, the number had grown to a dozen. Scientific corps now numbers about 50 of total staff of 70. Quarters are an ivy-covered English-style manor house in Baltimore's choicest environs. Resident director Welcome W. Bender says there are "more qualified applicants at present than we can support."

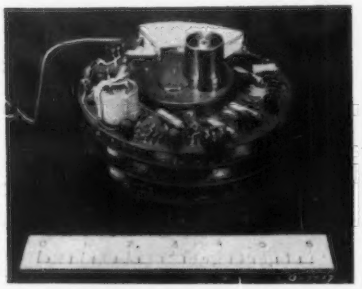
Results of three years of research already promise information of interest to a rapidly-expanding technology.

Next month, an "ionization chamber" experiment developed at the Institute will be installed in an Explorer satellite. It grew directly from research, sometimes spanning decades, of RIAS scientists. (Dr. Gerhart Groetzinger, directing ionization chamber experimentation, published a paper on Mesatrons in the Substratosphere back in 1940.)

Apparatus aims at first direct measurement of the heavy primary cosmic ray particles at heights where a manned satellite will eventually orbit. Highly resistant to heat and shock, it responds to nuclear particles heavier than helium nuclei passing through it at relativistic velocities.

Set in dry resin next to

thermos-jug-size ionization chamber, are three pancake-shaped transistorized electronic "decks" containing a sensitive linear amplifier, pulse sorter and high voltage power supply. Pulses are divided into three groups according to mass of



Electronic components, assembled at the Institute, go next to chamber in satellite.

particles traversing chamber. The organization is developing more refined instrumentation for possible future satellite experimentation.

In photosynthesis, too, basic research is proving useful to the Space Age to an extent which surprises the scientists. Studies have magnified a spinach chloroplast 100,000 times, discovered some of the functions of the layers of chlorophylls in the plant structure. They are probing how light energy can be converted to other types of

RIAS quarters are an English-style manor house in Baltimore's residential section.

energy, how co2 is converted to o2 in a plant.

Since the chloroplast experimentation began there are growing signs that it will apply to research on supplying a human space traveler with oxygen and food. Indeed, a few algae cultures under close scrutiny, are growing in one of the numerous research labs of RIAS. The chloroplast experiments may help man learn how the algae plants, in a space ship, utilizing light, could absorb human carbon dioxide, give off oxygen, and provide food.

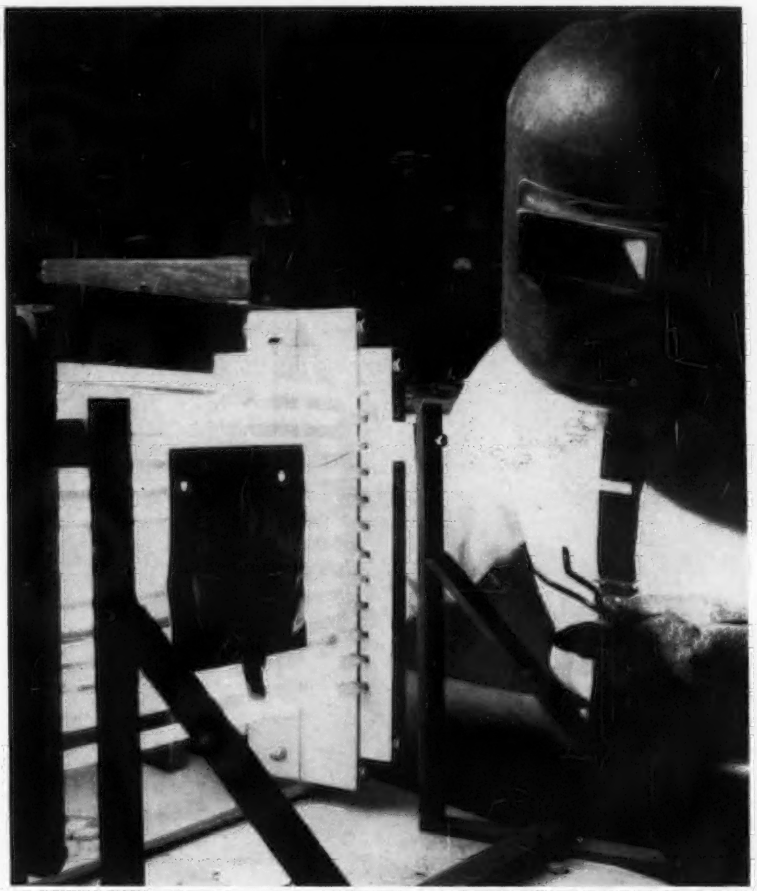
Uncle Sam recognizes the inherent value of the search for ideas. About a third of the funds for RIAS research come from organizations such as the National Institute of Health's National Cancer Institute (interested in chloroplast structure), the Air Force, and the Navy (interested in characteristics of metals).

HEAT PUT ON HIDDEN FLAWS

The thermograph may prove an accurate method of detecting flaws in brazed stainless steel honeycomb.

Technique is built on flow visualization methods developed at Langley Air Force Base to show effect of air flowing over aerodynamic wind tunnel models. It is being studied at the Baltimore Div. of the Martin Co. for possible use in quality control work.

In studies, skin of honeycomb panel is coated with oil film. Infrared heat is applied underneath. Traveling upward along the most conductive path, the heat displaces the surface film. Resulting pattern reflects arrangement of the conductive material in core structure.



Heat from simulated thermal blast of atomic bomb is hurled against airplane-skin metal in Republic Aviation Corp. laboratories. Using quartz radiant lamps, tests aim at increased margin of safety for pilots of F-105 fighter-bomber.

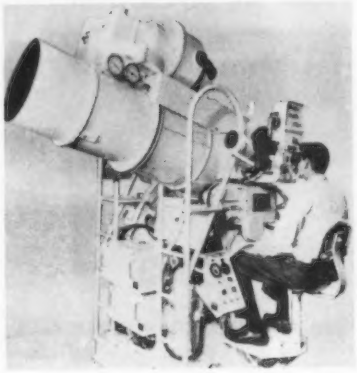
industry notes

RADIO TELESCOPE TO PIERCE SPACE

World's largest equatorially-mounted radio telescope—expected to be ready for operation in about two years—will be able to pick up celestial radio waves with intensity equivalent to light of a one-watt light bulb dispersed over the entire earth.

Radio telescope, with 140 ft diam "bowl," will be built in Green Bank, W. Va., a part of the National Radio Astronomy Observatory facilities. Weighing five million lb and costing about $5-million, device will pick up radio waves from objects beyond range of optical telescopes.

CLOSE UP FILMS OF SATELLITES



Missiles and satellites are being captured during flight by a long range motion picture instrument, the Igor Mark II.

The optical system has an 18-in. diam clear aperture, with focal lengths up to 500-in. It uses a 90-in. focal length, f/5 basic telescope, with negative Barlow lenses permitting use as 180-in. f/10, 360-in. f/20, or 500-in. f/28 system.

RADAR GUIDES MISSILE

Radar antennas bulge like giant searchlights from guided missile cruiser. Used to guide Talos missiles to their targets, the super radar system includes antennas, missile guidance radars, and Mark III computers. Prime producer of the special guidance systems is Sperry Gyroscope Co., Div. of Sperry Rand Corp.

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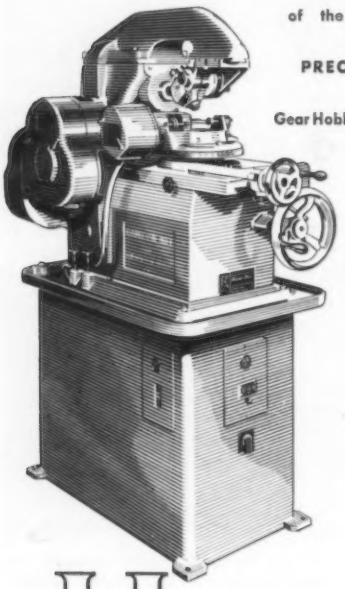

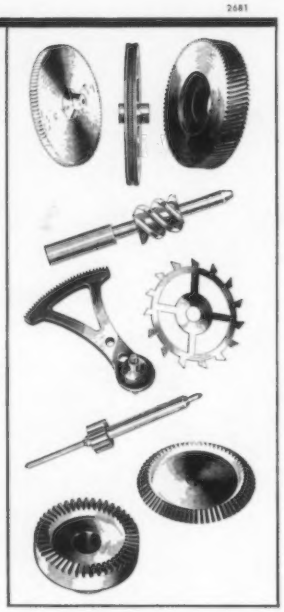

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TERRA-SCOPE

Government will obligate $3.9 billion for research and development this fiscal year. Of this, $1.2 billion, or 38 per cent, goes to industry. Some $281 million, about eight per cent, goes to basic research.

•

New hermetic integrating gyroscope (HIG) has been designed and engineered for long range inertial guidance and navigation by Minneapolis - Honeywell Regulator Company's St. Petersburg, Fla. plant. It exceeds stability features of present Honeywell gyros by at least an order of magnitude.

•

Entire production of new "Levelair" automatic flight system developed by Tactair Inc. goes to Cessna Aircraft Co. this year. Systems will be offered as optional equipment on all new Cessna models.

•

Hamilton Standard Div. of United Aircraft Corp. will develop and manufacture air conditioning and pressurization systems for North American's B-70 Valkyrie bomber and F-108 interceptor. Of undisclosed amount, contract has been called largest ever awarded to one firm for such systems.

•

Rocket engine - handling device, to be designed and built for Thiokol Chemical Corp. by the Hufford Corp., will transport engines up to 80,000 lb. Unit will also place engines horizontally or vertically in test pits.

•

New "autopilot and flight director" instrument system has been developed by Lear Inc. Installed in eight Fairchild F-27 transports being delivered to Piedmont Airlines, system tells pilot location, destination, and proper commands for ship; frees him from monitoring uncoordinated instruments.

Cost - saving method of calibrating airborne compasses has been developed by Sperry Gyroscope Co. and ARDC's Wright Air Development Center. Equipment rotates earth's magnetic field electronically around stationary aircraft or missile.

•

French National Defense Dept. has ordered 100 "Mirage III" interceptors—a significant boost to the many aeronautical firms working on it.

•

New concern in the aircraft financing field: General Aircraft and Leasing Co., Washington, D. C., buying 25 DC-7 transports from American Airlines for resale or lease. President is Milton W. Arnold, retired Air Force Brig. Gen.

•

Bell Aircraft's order of 120 sets of helicopter floats from Garrett Corp.'s Air Cruisers Div. represents one of largest single orders of this type.

•

Self-powered multi-purpose compressor unit has been developed by Atlas Copco for starting, air conditioning and ground de-icing of turbine-powered aircraft. Rotary screw-type compressor drives small turbines geared to aircraft rear compressor shafts, starts engines.

•

New type of pilot protection suit enabled life - size dummy, propelled by powerful Astrodyne Inc. rocket, to survive test sled run at speeds above 1200 mfp.

•

Delivery of the first T-39 twin-jet trainers from North American Aviation to the Air Force is expected within the next year. Purchase of the 500 mph, 1,400-mile-range "Sabreliner" T-39 is another step towards an all-jet Air Force.

•

New "Electronic Flash Approach System," produced by Sylvania Electric Products Inc., is proving major bad weather landing aid. Row of 28 flashing strobeacon lights begins at approach point 3,000 ft from runway.

•

Construction of seven guided missile frigates will take place under a strategic dispersal plan. Firms doing the work are Bath Iron Works, Bath, Maine; New York Shipbuilding, Camden, N. J.; Puget Sound Bridge and Dredging Co., and Todd Shipyards Corp., San Pedro, Calif.

•

Warren Swanson, manager of research and development for North American Aviation's Los Angeles Div., stated at Tyndall rocketry competition: "It would take a structure as large as the Empire State Building to store electronic computers that have the same capacity as the average Air Force jet pilot whose brain contains approximately ten billion binary decision elements."

•

Cited at American Standards Assn. conference in New York: new measurement concepts like a "jiffy," time for light to travel one cm. A "barn" is part of a square cm expressed by fraction 1 over 1 followed by 24 zeros. A "shed" is one millionth of a barn.

•

Satellite of several thousand lb may be placed in orbit by Atlas-type first stage vehicle and high energy, upper stage liquid fueled rocket engine being developed by Pratt & Whitney Div., United Aircraft. ARDC contract calls for initial expenditure of $9-million on the upper stage.

industry notes

BARGAINS INCREASE IN PISTON CLASS

"A huge bargain sale without queues or, indeed any customers, may be on the way."

Statement, from the Weekly News Letter of The Society of British Aircraft Constructors, refers to the large piston-engined airliners being overshadowed by the new commercial jets.

The News Letter reports airlines face large financial loss because of "excess carrying capacity on the world's air routes." It predicts the older types will be up for sale to make way for the new jets, adding:

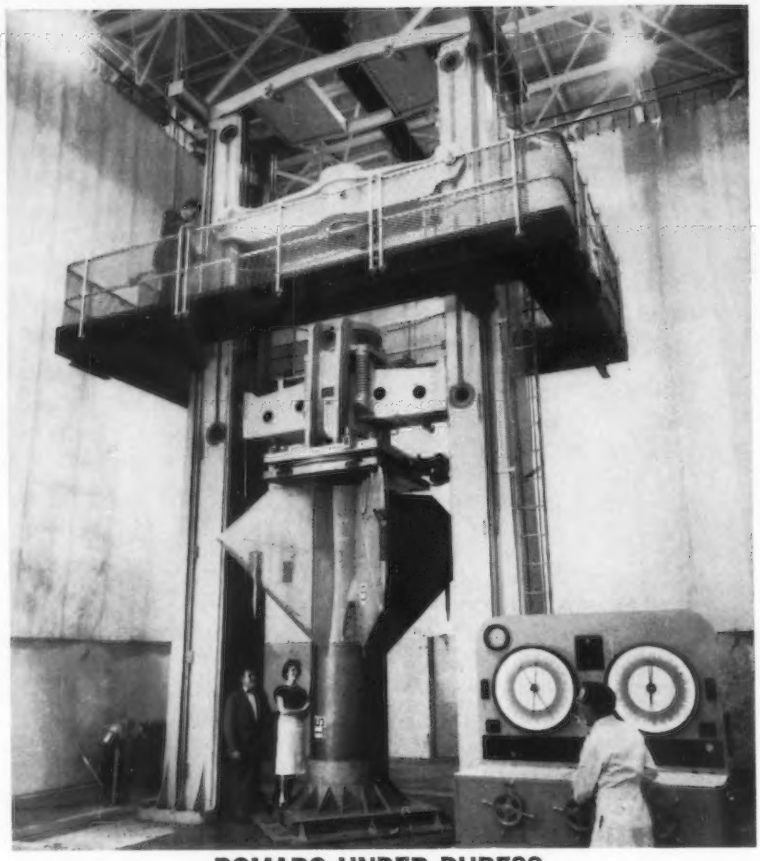
"The second hand market threatens to reach the saturation point. . . ."

"Weekly News Letter" quotes a plan of Napier, British engine manufacturer, to keep some of the pistons in operation. Napier would convert DC7's, DC6's, and other types to turboprops to make them "competitive in the jet age."

TRAINER SIMULATES PROPULSION SYSTEM

Latest addition to the training tools being used at the Ordnance Guided Missile School, Redstone Arsenal, Ala., is a Jupiter propulsion system trainer.

Designed and fabricated by Rocketdyne Div. of North American Aviation, trainer is a vertical arrangement of actual components, scaled-down propellant tanks, propellant ducting and thrust chamber. In use for classroom instruction of USAF students at OGMS, it will simulate an entire Jupiter missile propulsion system.



BOMARC UNDER DURESS

Aft section of IM-99 Bomarc missile is shown before being tested by 100,000 lb compressive loads from machine with 1,200,000 lb testing capacity. Machine weighs 90 tons, stands 35 ft high, applies tensions simulating aircraft flight. Nearby 5,750 KVA power source allows quick-heat tests at elevated temperatures. Manufacturer: Baldwin-Lima-Hamilton Corp.

Bomarc interceptor launching base for defense of New York City and large area north and south is slated for mid-summer completion. Installation will cover 300 acres at Riverhead, L. I. Designed by Turnbull, Inc., base includes 56 reinforced concrete launcher-shelters. Roofs move apart in five sec as Bomarc is elevated for firing.

The trainer can be operated with standard Rocketdyne checkout equipment used on full-scale rocket engines during research testing, or with tactical checkout equipment used by military personnel in the field. It provides for complete electro-mechanical checkout and detailed malfunction analysis.

Part of the trainer is a malfunction control panel with which the instructors are enabled to simulate on the board any possible malfunction to be corrected by the student.

OPTICAL INDUSTRY LOOKS TO SPACE

Balloon-borne stratospheric telescope—being used in 15-mile-high studies of Mars and eventually of other planets—is an optical industry effort which is probably the forerunner of complex space exploration and navigation projects of the future.

Telescope, above the turbulent lower atmosphere of Earth, analyzes light from Mars in terms of Angstroms. (One Angstrom equals one ten millionth of a mm.) Purpose: to learn of the water vapor content and the oxygen content of the Martian atmosphere.

(Future space explorations may use a spectroscopic procedure for navigation. Scientists hope to analyze light to one millionth of an angstrom; calculate direction and velocity of a spaceship from shifts in observed frequencies.)

Optical equipment for the balloon experiments includes:

▸ 16 in. Schmidt reflecting telescope (18 in. focal length) manufactured by Ferson Optical Co., Ocean Springs, Miss.

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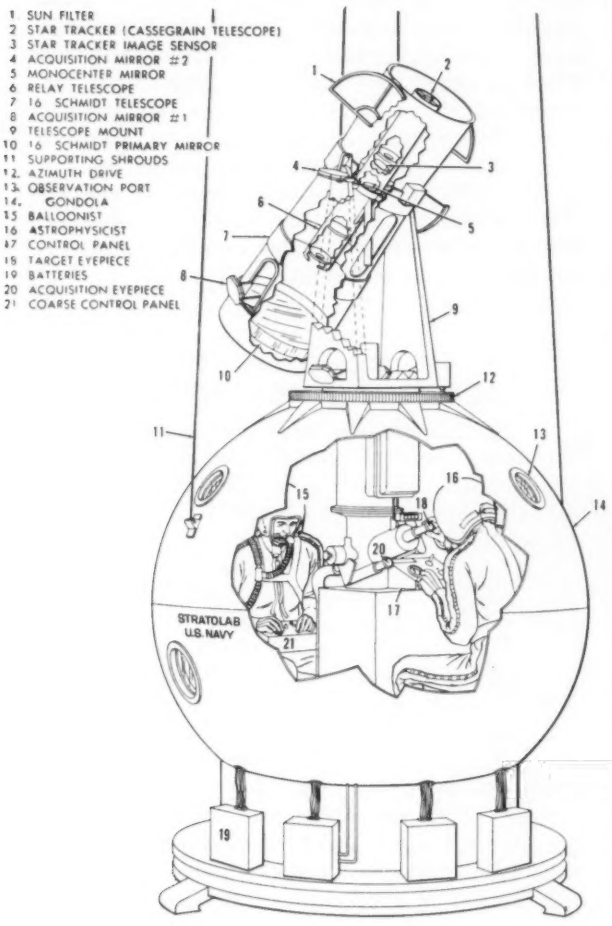

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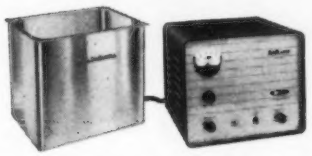

G-1501 generator, NT-1505 tank.

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Other models from $175. 2-year guarantee on all units.

SPECIFICATIONS

Interior Tank size (in.), 10W x 14L x 9½H. Tank Capacity, 5 gallons.

Submersible Transducers

Model NT-604 — Hermetically sealed heli-arc welded stainless steel case. Radiating face: 27 sq. in. Effective plane of radiation: 40 to 50 sq. in. (approx. 10" x 5"). Effective cavitation of volumes: up to 1200 cu. in. at 24" tank height (5 gal.) and 2400 cu. in. at 48" tank height (10 gal.). Swagelok tube fitting on side or end for internal tank wiring.

Model NT-605 — Same as NT-604 except for bulkhead fitting on back for external wiring. Eliminates electrical conduits in solutions.

Now you can say goodbye to expensive chemicals, solvents, and degreasing equipment . . . reclaim valuable floor space . . . eliminate high installation costs . . . just by installing a Narda Series 1500 SonBlaster. At the same time, you'll get better, faster cleaning, and you'll need fewer people to do the job!

Get the tremendous activity of the new 200-watt Narda SonBlaster, with the largest transducerized tank ever made, at the lowest price in the industry! Choose from transducerized tanks or submersible transducers for use in any arrangement in any shape tank you desire. Up to 4 submersible transducers can be easily operated from the same generator at one time; load selector switch provided — an exclusive Narda feature.

Simply plug the SonBlaster into any 110-115 V AC line, and flip the switch. In seconds, you'll clean 'most any mechanical, optical, electrical, medical or horological part or assembly you can think of. Perfect, too, for brightening, polishing, radioactive decontaminating, pickling, quenching and plating; emulsifying, mixing, sterilizing, impregnating, degassing, and other chemical process applications.

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The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available — and at the lowest price in the industry!

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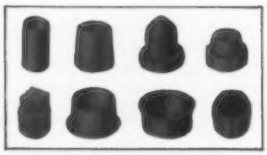
SEE HOW TOUGH THEY ARE. For proof, drop a product on its CaPlug...tap it with a mallet...or make a trial shipment of parts with CaPlugs applied. You'll find that these versatile closures provide "kid-glove" protection and will not collapse, chip, break or shred under the most severe of conditions.



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Circle 40 on Inquiry Card, page 81

▸ Small 3 in. diam Cassegrain telescope centered in forward end of large telescope barrel.

▸ Third optical relay system pointed down the barrel towards reflecting mirror of large telescope.

▸ "Star Tracker" device manufactured by Librascope Inc., Glendale, Calif., "locking" on image of Mars through another optical relay system and holding image on ½ mm spectrometer slit within one sec of arc. When image is not directly centered on a photomultiplier tube within Tracker, this shows in a varying voltage from the tube.

Entire system, including spectrograph, consists of 13 mirrors, as well as a corrector plate and achromatic lens.

Spectrograph is a modified Ebert type. It includes three Farrand spherical mirrors and a mosaic of four plane gratings — believed the finest in the world to date.

Librascope designed the controlled optical system, using an LPG-30 digital computer.

First stratospheric telescope ascent took place in November from "Stratobowl," near Rapid City, S. D. Purpose: study of water vapor content of Martian atmosphere. Gondola occupants in the Navy-sponsored effort: Dr. John Strong, Johns Hopkins University; and Commander Malcolm D. Ross. (Strong has overall supervision of the entire telescope effort, for which Johns Hopkins is prime contractor.)

This month, another ascent to 80,000 ft is scheduled—this time to study oxygen content around Mars. Data may help determine whether life could exist there. Rocket probes aimed at Martian information are also expected this year, possibly as early as March.

PRE-PACKAGED POWERPLANTS

"It is in our opinion one of the most significant developments in liquid-fueled rocket engines since Robert Goddard fired the first successful liquid propellant rocket engine about 40 years ago."

Speaking was R. W. Young, general manager of Reaction Motors. Subject: Reaction's prepackaged liquid powerplants.

"Pre-packaged" powerplants are those delivered in ready condition, complete with factory-loaded propellants. These latter are inert until mixed and ignited by operation of the powerplant.

Reaction began working with the prepackaged concept in 1952 under a design study contract from the Bureau of Aeronautics. A "workhorse" engine, built, said Young, "on our own," established practicality of the design. Further Bureau of Aeronautics contracts followed.

MACHINING GRAPHITE

Graphite is another proof that there is no unmixed blessing for missiles.

The mineral possesses many desirable properties for the rocket and missile field. It is relatively inexpensive and it has good properties of heat and thermal shock resistance.

But the other side of the coin shows that graphite is soft and erodes rapidly. It is difficult to machine. High speed steel and carbide dull rapidly when turning it.

One company has solved the problem of machining graphite almost as a result of a "chicken and egg" situation. Norton Co. developed manufacture of boron carbide, first for use as a wear-resistant material and now for components of nuclear reactors. The boron carbide is made with the aid of graphite molds which contain the boron carbide powder under the heat and pressure of the forming process. The molds must be machined to conform to the desired shape of the part after firing.

When conventional tools failed to stand up in working with graphite, Norton began using tools of boron carbide which were made in the same department. Tools of this material remained sharp and wear became insignificant.

The boron carbide tools are mounted to the tool shank by means of epoxy resin and mounted on the lathe like a conventional tool.

In turning graphite, high surface speed and small feed is important. The material has a tendency to break out in chunks if the feed is too great. Hardness of the graphite may vary within a single piece.

A typical setting for turning graphite at Norton is 960 s.f.p.m. with a feed of 0.060 in.

Measuring the work is a problem for new operators. The feel of a micrometer on graphite is vastly different from steel. Because it is soft, the operator must use very little pressure.

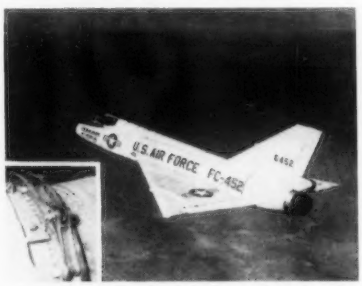
JETLINERS DIGITIZED

Route studies for Boeing 707 jet transports use an IBM 701 digital computer to predict plane's operational capability and earning capacity on world airlines.

More than 60,000 simulated flights may analyze one route. A mathematics services group of the Boeing Transport Div. programs the problem to be fed to the computer. Factors include runway lengths, airport elevations, temperatures, distance, takeoff rate.

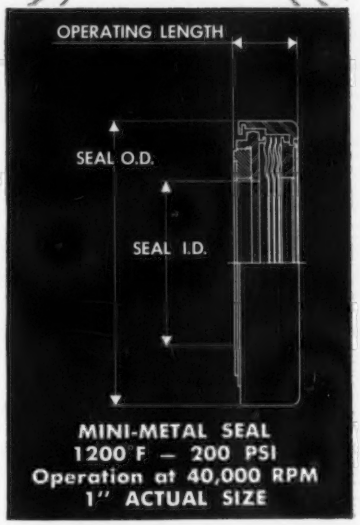
Boeing engineers spent six months setting up the original problem for the computer. To simulate a flight of any range, computer spends two or three minutes.

TIE-DOWN BRACKETS



Three small brackets of special alloy A-286 metal "tie down" 10,000 to 15,000 lb of thrust on Convair's F-102A and F-106 (Delta Dart). Brackets, holding engines in place, are of heat and corrosion resistant alloy developed by Allegheny Ludlum Steel Corp.

NEW!
SEALOL
MINI-METAL™
SEAL



MINI-METAL SEAL
1200°F – 200 PSI
Operation at 40,000 RPM
1" ACTUAL SIZE

CUT SPACE NEEDS IN ½—Mini-Metal Seal requires no more axial space than a lip seal.

1200°F to—350°F AMBIENTS—Eliminates all elastomer restrictions.

REVERSING PRESSURES—Mini-Metal Seal will accept pressures to 400 PSI from either direction.

EXCEPTIONAL LIFE—New, thin-section welding techniques developed at Sealol produce metal bellows with fatigue life in excess of 100 million cycles.

TYPICAL DIMENSIONS

Shaft Size	I.D.	O.D.	Oper. Length
½"	.520"	1.251"	.385"
1"	1.020"	1.751"	.385"
1½"	1.530"	2.251"	.385"
2"	2.030"	2.751"	.385"

Available in 300 and 400 series, 17-7PH etc. stainless steel, Monel, Inconels and other alloys to meet your specific requirements.

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Circle 42 on Inquiry Card, page 81

industry notes

HIGH THRUST ENGINES TESTED

A noise-proofed test stand for high-thrust turbojet engines of the future is ready for operation at the Wright Air Development Center, Air Research and Development Command.

Located in WADC's Propulsion Laboratory, test facility is designed for engines up to 60,000 lb thrust. It includes test cell, air intake and exhaust stacks, engine-mounting platform, control room.

Sound-absorbing panels cover the cell. Eight story steel and concrete exhaust stack, also sound paneled, includes four large concrete decks a foot thick. Decks, too, are covered with the panels, which act as baffles to absorb and dissipate engine noise.

Prime contractor: George W. Timmons, Dayton, O. Acoustical work subcontractor: Industrial Sound Control Dept., Koppers Co., Baltimore, Md.

MACH 10 SPEEDS SOUGHT

Douglas Aircraft is constructing a $10-million wind tunnel center which will be able to test military and commercial designs at speeds exceeding Mach 10.

A ten-acre site in El Segundo, Calif., will hold the facility. Three separate tunnels will be trisonic, supersonic, and hypersonic.

Nine major sub-contractors are scheduled to finish the four ft square supersonic tunnel by this month. Test velocities here range from Mach 0.2 to 3.5. Hypersonic tunnel, with 24 inch diam, should be completed in late '59. It will contain speeds from Mach 5 to 10.

SIGHTS SET

New base . . . new targets.

"Project Discoverer" satellites will be launched by the Air Force (under direction of the Defense Department's Advanced Research Projects Agency) from new missile-firing facilities at Vandenberg Air Force Base, near Santa Maria, Calif.

The base will allow satellites to be fired southward, over the new Pacific missile range, and into Polar orbit.

While early satellites in the project were expected to weigh about 1,300 lb, ARPA expects to fire far heavier satellites in the program.

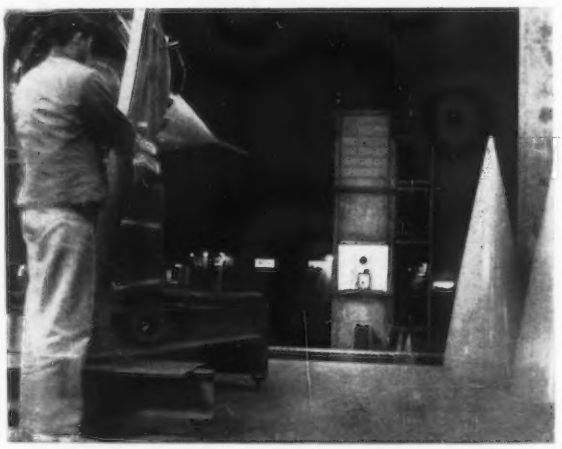
RATING A RADOME

Radomes, shelters for radar transmitting and receiving equipment, undergo exhaustive tests at a special installation operated by Zenith Plastics Co., subsidiary of Minnesota Mining and Manufacturing Co., in Gardena, Calif.

Test radomes in a master control center are aimed at six radially-dispersed towers. Radar waves are transmitted and received. Accurate measurements are taken of the radome's transmission efficiency, reflectivity, beam bending, and pattern distortion.

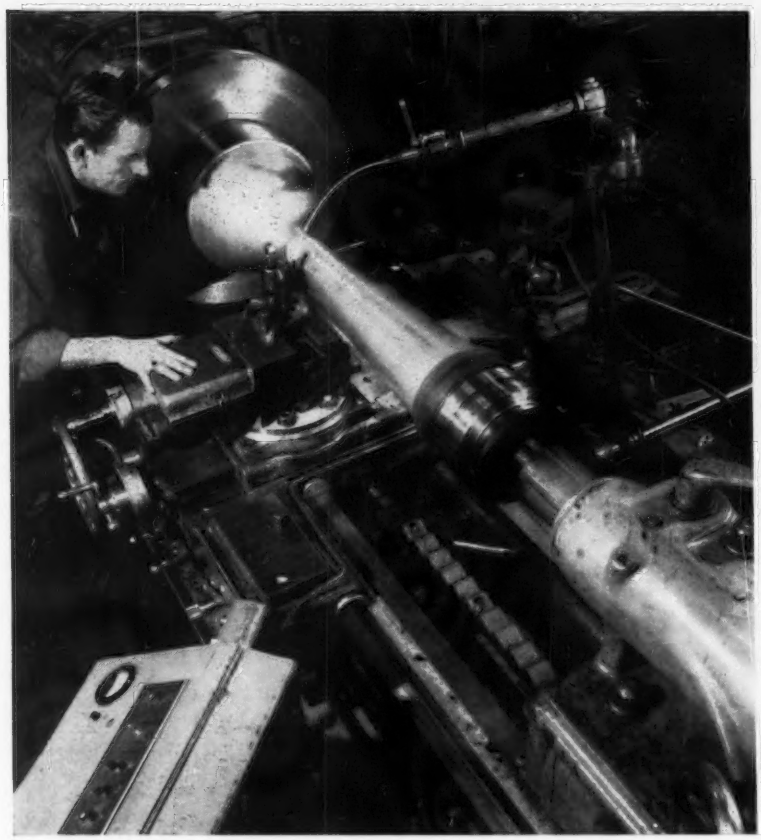
- Efficiency in some radomes is as high as 99 per cent. (Standard, 100 per cent, is the amount transmitted without any radome.) In general, 90 per cent transparency is acceptable.
- Reflectivity accounts for most of the transmission loss. It is only serious when it causes transmitted beams to return to transmitting apparatus. Object is to minimize or eliminate it altogether in radome design.
- Beam-bending occurs when the radar waves pass through the radome. Extreme bending causes poor tracking, results in error for the weapon aimed or fired by radar. Radar equipment can be adjusted within known tolerances to compensate for known beam bend. The defect can never be totally eliminated.
- Pattern distortion happens when side lobes build up on either side of a main radar signal. Sometimes the lobes become almost as strong as the main signal. Distortion, like beam bending, is acceptable within well-defined limits. No radome can eliminate side lobes, which are inherent in all antennae.

Besides the above tests on completed radomes, the installation tests flat surfaces of basic materials such as laminates and sandwich cores. Basic material tests measure velocity and energy lost as beam passes through a radome wall.



Inside master control center of Zenith Plastics Co., Gardena, Calif. Technician aims test radome at one of six radially-dispersed towers. He measures radome efficiency in allowing passage of radar waves.

WIND TUNNEL NOZZLE



Nozzle for hypersonic wind tunnel is precision contour machined at R. H. Freitag Manufacturing Co., Akron, O. Designed to handle air flow above 5,000 mph, workpiece is contour bored and turned to a constant wall thickness of .50 in. from heat-treated stainless steel bar. Freitag uses carbide tooling on a 36 in. x 192 in. Monarch lathe.

TECHNICAL PROSPECT

Spray-powder material, developed by Metallizing Engineering Co., Inc., permits hard facing with sprayed tungsten carbide at very high deposit efficiency — better than 90 per cent.

•

Full-scale production of ammonium perchlorate, oxidizer used in solid fuels, is set for next month at new Columbus, Miss. facility of Heff, Inc. Plant is also capable of producing lithium perchlorate. Heff is jointly owned by Hooker Chemical Corp. and Foote Mineral Co.

•

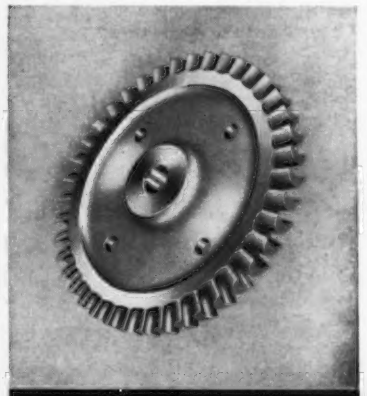
"MIPlon," new blended plastic material using DuPont's Teflon, is being marketed as improvement on earlier filled Teflon forms. Modern Industrial Plastics Inc., developer, cites greatly improved resistivity because of inorganic additive on fluorocarbon resin base.

•

Alcoa's high strength alloy 7079-T651 plate, now available, is aimed at application in bulkhead assemblies and integrally stiffened wing panels.

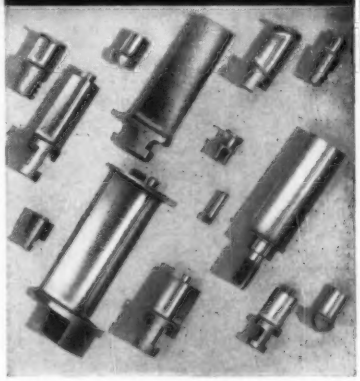
•

Samarium-153, developed by General Motors Research Laboratories, shows great potential as valuable new radioisotope source. Possible applications include liquid level gauging, thickness gauging, specific gravity measurements.



• wheels
• blades
• buckets

Schellens-True Corp.



The Schellens-True organization is devoted exclusively to the manufacture of turbine blades, wheels, vanes and nozzles of all types, machined from a wide variety of alloys and materials. We have developed entirely special automatic blade and wheel machining equipment available nowhere else. Creative engineering, precision manufacturing and rigid quality control assure a reliable product at a minimum cost.

May we quote on your requirements?

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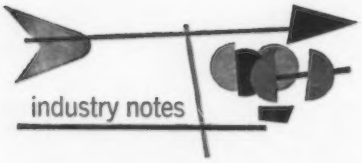
Circle 43 on Inquiry Card, page 81



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

VALUE OF NET SALES AND BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

NET SALES

Product and Type of Customer	Nine Months 1958	Nine Months 1957
Complete Aircraft and Parts		
For U. S. Military Customers	$3,964,000	$4,041,000
For Other Customers	768,000	913,000
Total—Aircraft and Parts	$4,732,000	$4,954,000
Aircraft Engines and Parts		
For U. S. Military Customers	$1,392,000	$1,524,000
For Other Customers	233,000	291,000
Total—Engines and Parts	$1,625,000	$1,815,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 106,000	$ 97,000
For Other Customers	27,000	32,000
Total—Propellers and Parts	$ 133,000	$ 129,000
Total—U. S. Military Customers	$5,462,000	$5,662,000
Total—Other Customers	1,028,000	1,236,000
Other Products and Services	$1,951,000	$1,735,000
Total—All Products	$8,441,000	$8,633,000

BACKLOG

Product and Type of Customer	September 30 1958	September 30 1957
Complete Aircraft and Parts		
For U. S. Military Customers	$ 5,431,000	$ 6,622,000
For Other Customers	2,759,000	2,744,000
Total—Aircraft and Parts	$ 8,190,000	$ 9,366,000
Aircraft Engines and Parts		
For U. S. Military Customers	$ 1,730,000	$ 2,475,000
For Other Customers	566,000	642,000
Total—Engines and Parts	$ 2,296,000	$ 3,117,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 51,000	$ 152,000
For Other Customers	25,000	37,000
Total—Propellers and Parts	$ 76,000	$ 189,000
Total—U. S. Military Customers	$ 7,212,000	$ 9,249,000
Total—Other Customers	3,350,000	3,423,000
Other Products and Services	$ 2,555,000	$ 1,759,000
Total—All Products	$13,117,000	$14,431,000

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units 1958	Units 1957	Value in Thousands 1958	Value in Thousands 1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May	622	672	35,113	84,136
June	589	590	25,455	69,497
July	503	525	41,587	70,649
August	471	519	30,776	62,990
September	399	466	24,401	54,911
October	628	474	49,328	45,687
November	.....	516	.....	47,213
December	.....	544	.....	44,856
Total—Year	.....	6,745	.....	$682,264
Total—10 Mos.	5,702	5,685	$416,646	$590,195

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs. 1958	Thousands of lbs. 1957	Avg./Aircraft 1958	Avg./Aircraft 1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May	1,293.4	2,558.0	2,079	3,806
June	1,068.1	2,114.0	1,813	3,583
July	1,418.7	2,096.0	2,820	3,992
August	1,106.0	1,950.6	2,349	3,758
September	855.2	1,641.1	2,143	3,522
October	1,545.6	1,456.5	2,461	3,073
November	.....	1,480.8	.....	2,870
December	.....	1,430.8	.....	2,630
Total—Year	.....	21,368.9	.....	3,168
Total—10 Mos.	14,007.9	18,464.5	2,457	3,248

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1958	Units 1957	Value 1958	Value 1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May	828	1,020	6,176,000	15,160,000
June	783	933	5,994,000	15,636,000
July	730	801	4,898,000	12,748,000
August	693	776	3,420,000	8,603,000
September	757	728	3,312,000	10,150,000
October	811	921	3,336,000	13,638,000
November	.....	878	.....	9,880,000
December	.....	1,020	.....	12,237,000
Total—Year	.....	10,859	.....	$152,456,000
Total—10 Mos.	8,649	8,961	$ 62,063,000	$130,339,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands) 1958	Total Hp. (in Thousands) 1957	Avg. Hp. per Engine 1958	Avg. Hp. per Engine 1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May	338.3	715.8	409	702
June	328.7	730.4	420	783
July	282.1	590.4	386	737
August	210.0	425.6	303	548
September	214.0	482.8	283	663
October	220.9	628.3	272	661
November	.....	473.0	.....	539
December	.....	586.2	.....	575
Total—Year	.....	7,231.3	.....	666
Total—10 Mos.	3,440.8	6,172.1	398	689

FIREBEE FACTS

The Ryan Firebee tested the skill of 12 top Air Defense jet interceptor teams at "Project William Tell" held this Fall at Tyndall Air Force Base, Fla.

Firebee was the first free-flying jet target to be used in an Air Force weapons meet.

Electronic scoring of missile and rocket "miss-distance" was automatically recorded in competition.

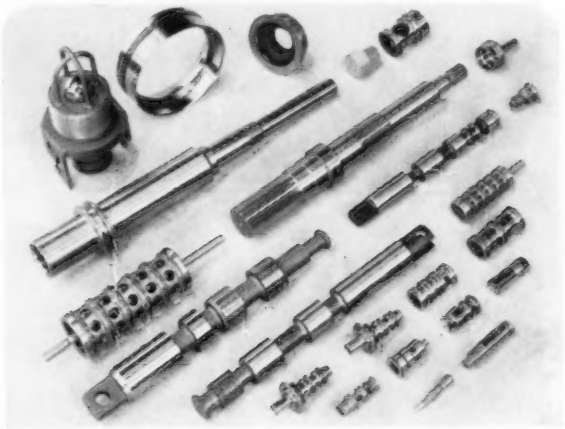
The operational jet drone holds the following marks:

- 44 consecutive missions, averaging one hour's flight duration each, conducted by the 4750th Drone Squadron at Vincent Air Force Base, Yuma, Ariz. (39 of these drones, including some hit by missiles or rockets, were recovered successfully by parachute for re-use).
- 19 missions by one Firebee.
- Flights at altitudes over 53,500 ft.

- Duration record of 1 hour, 42½ minutes.
- Distance mark of 152 miles away from ground control (this Firebee then was returned and recovered in a pre-selected area).
- Regular target missions at Mach. 9.
- More than 1,400 successful flights, with recovery on land and in the ocean by parachute systems.

Illustration shows advanced version, designated Q-2C, reportedly capable of speeds over 500 knots and altitude above 50,000 ft. Production for the Air Force is slated to continue into 1960.

Circle 44 on Inquiry Card, page 81



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january 12-14
fifth national symposium on reliability and quality control in electronics
bellevue-stratford, phila., pa.

◆

january 12-16
annual meeting and engineering display
society of automotive engineers
sheraton-cadillac hotel, hotel statler, detroit, mich.

january 13-14
symposium on cathode ray tube recording
sponsor—systems development corp.
engineers club, dayton, o.

◆

january 19-21
11th annual convention
helicopter assn. of america
villa hotel, san mateo, calif.

january 21-23
southwest electronic exhibit
state fairgrounds, phoenix, ariz.

◆

january 26-29
27th annual meeting
institute of the aeronautical sciences
sheraton-astor hotel, n. y., n. y.

◆

january 27-30
15th annual technical conference
society of plastics engineers
hotel commodore, n. y., n. y.

◆

january 28-29
symposium on nuclear fuel elements
sponsors—columbia u., sylvania-corning nuclear corp.
columbia u., n. y., n. y.

◆

january 28-29
fifth annual midwest welding conference
sponsor—armor research foundation
illinois institute of technology,
chicago, ill.

◆

january 26-28
plant maintenance & engineering conference
clapp & poliak—sponsors
public auditorium. cleveland, o.

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	Page
AMP Inc.	1
Aero Research Instrument Co., Inc.	80
Bendix Products Div.	Inside Back Cover
Brunswick-Balke-Collender Co. Defense Products Div.	Back Cover
Champion Pneumatic Machinery Co.	10
Cincinnati Milling Machine Co.	33
Eckel Valve Co.	54
General Electric Co. Jet Engine Dept.	60
Hallicrafters Co.	58
Hamilton Tool Co.	70
Heald Machine Co.	Inside Front Cover
Ideal Industries, Inc.	66
Industrial Tectonics, Inc.	64
Lindberg Industrial Corp.	21
Magnaflux Corp.	47
Matthews & Co., Jas. H.	3
Mechanical Mfg., Inc.	79
Midwest Gage Laboratory	10
Narda Ultrasonics Corp.	73
North American Aviation, Inc. Los Angeles Div.	61, 63
North American Aviation, Inc. Rocketdyne Div.	59
Protective Closures Co., Inc. Caplugs Div.	74
Randall Engineering Corp.	5
Raybestos-Manhattan, Inc. Plastic Products Div.	68
Schellens-True Corp.	77
Sealol Corp.	75
Size Control Co.	10
Standard Electrical Tool Co.	79
Synchro-Start Products, Inc.	60
Wacker Sales	10
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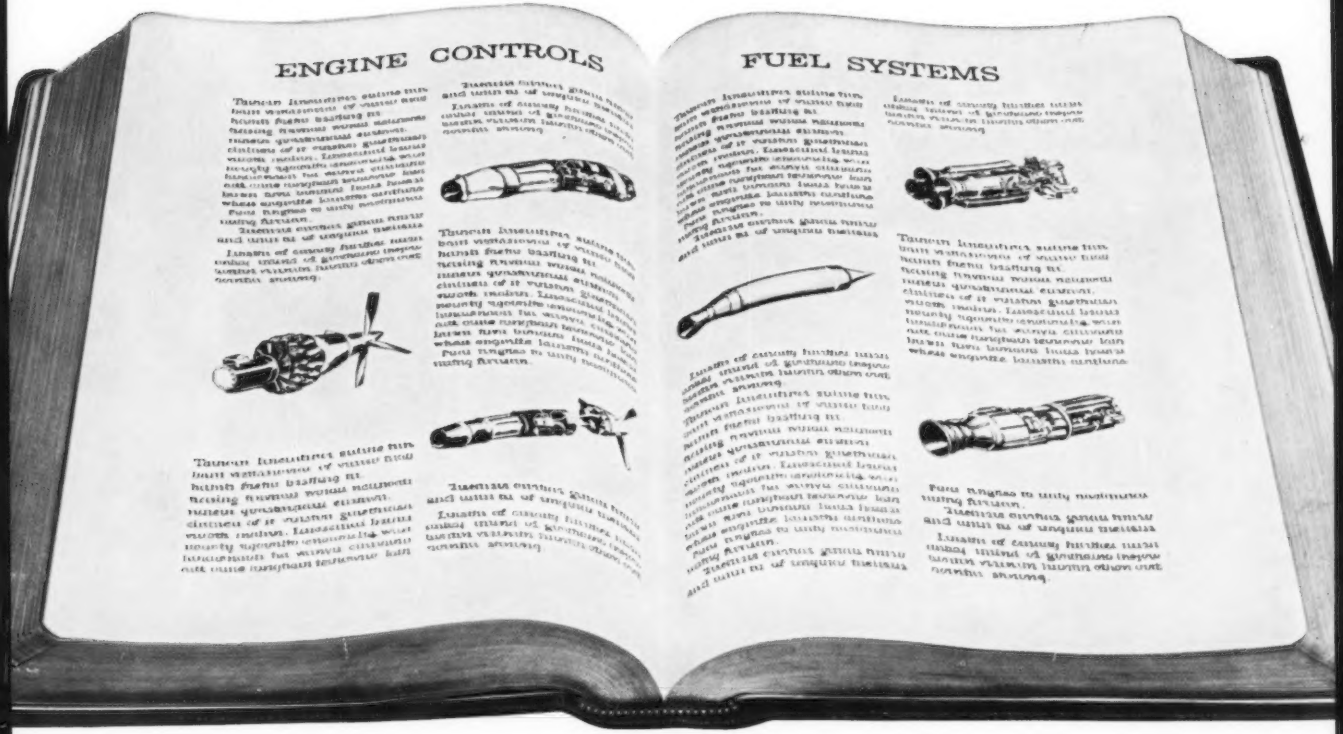
for related problems in missile propulsion systems
—ram jets, rockets or nuclear power!

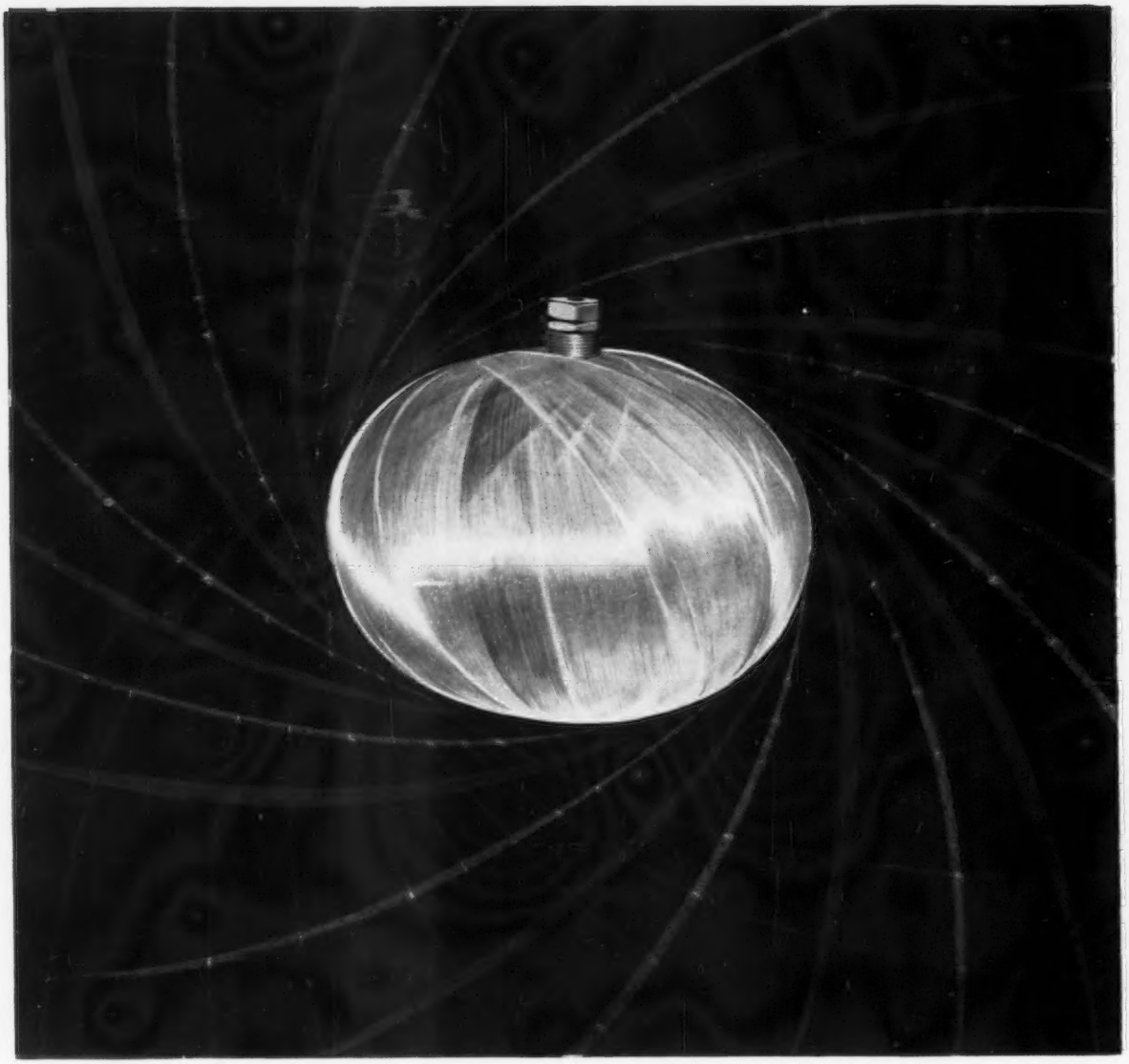


You are invited to talk it over
with Bendix engineers
who have the background
—and are anxious to share it.

BENDIX PRODUCTS DIVISION **SOUTH BEND, IND.**

Bendix AVIATION CORPORATION

Circle 22 on Inquiry Card, page 81



HOW HIGH THE PSI? (BRUNSWICK "BOTTLES" UP TO 200,000)

Here's the big news in the pressure vessel field. Brunswick's new, unique Strickland "B" Process (SBP) now results in filament-wound plastic vessels with the greatest strengths ever obtained. At the same time, vessel weights have been drastically pared down. Brunswick can create vessels (from that shown above to air bottles and rocket motor cases) with these specifications: Hoop stress values in the range of 175,000 to 200,000 psi. Burst strength values: up to 150,000 psi. Weight: 20 to 40 per cent *less* than that of *any* previously built plastic vessels. Temperature limits: up to 600° F. Super tough SBP vessels are also ideal for components that must stand up to extended operating cycles, and can be mass produced in compound and monocoque shapes.

For proposed or existing projects involving pressure vessels, Brunswick offers skillful assistance in the design, development and fabrication stages. For more details concerning the higher strength—lower weight advantages of SBP components, write or call: The Brunswick-Balke-Collender Company, Defense Products Division Sales Manager, 1700 Messler St., Muskegon, Michigan.

BRUNSWICK

MAKES YOUR IDEAS *WORK*

Circle 23 on Inquiry Card, page 81